COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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Cutler Station of Florida Power & Light Co.

Johnsonville Steam Plant of the TVA

New Central Station Cost Figures

ASME Annual Meeting

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PUBLIC SERVICE ELECTRIC AND GAS COMPANY

The C-E Unit illustrated here is now in process of erection at the Sewaren Generating Station of the Public Service Electric and Gas Company at Sewaren, New Jersey.

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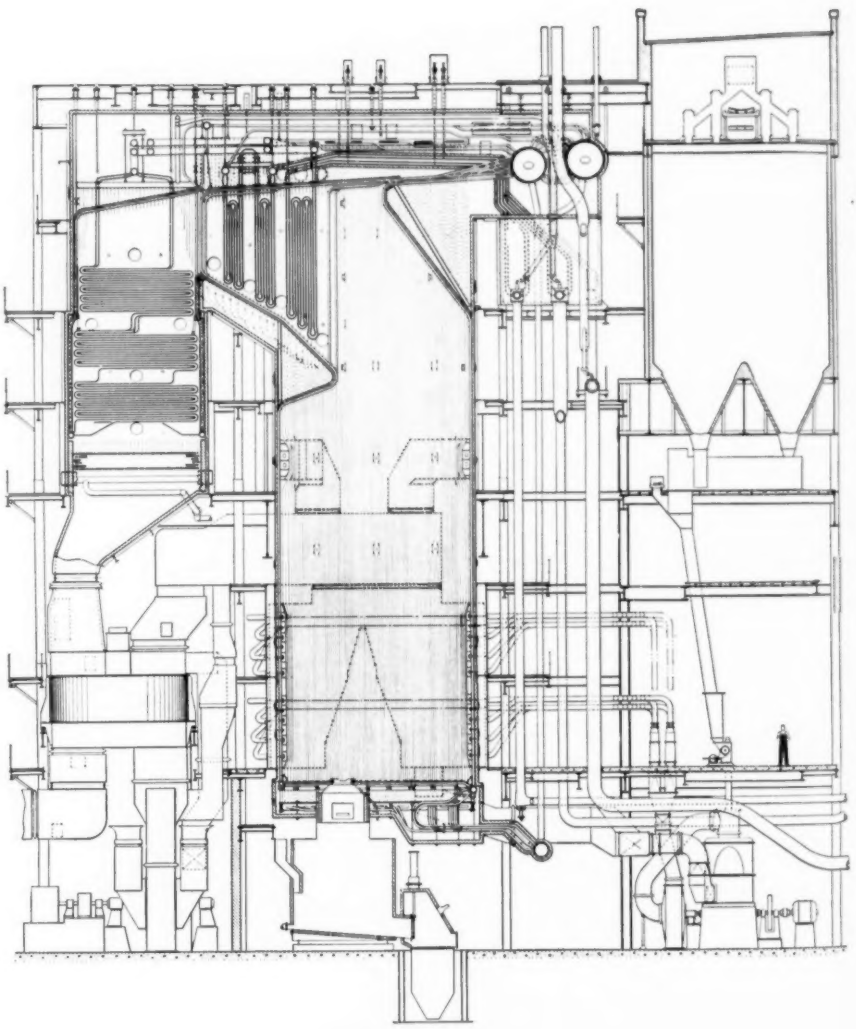
Pulverized coal firing is employed, using bowl mills and tilting tangential burners. Provision is made to use oil and natural gas as alternate fuels. B-417



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COMBUSTION

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Vol. 22 **No. 6**

December, 1950

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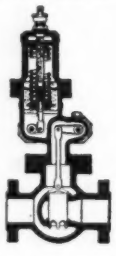

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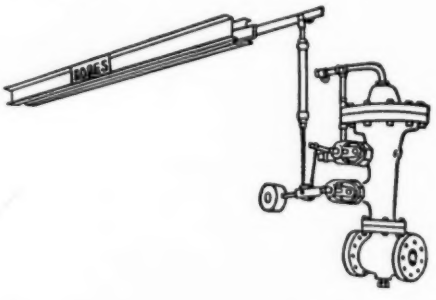

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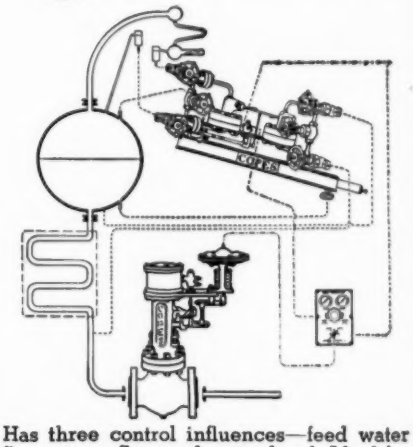

Has three control influences—feed water flow, steam flow and water level. Ideal for the ultra-modern high duty steam generators. Independent of other boiler instruments and controls; will remain on full-automatic when they are out of service for routine servicing. Can control through hydraulic couplings. *Leaflet P-25.*

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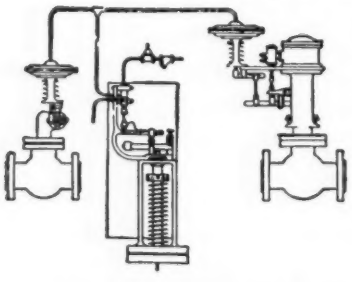
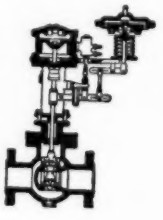


Built for jobs too tough for ordinary stock valves. Each is individually designed for your specific needs, with accuracy and dependability guaranteed. Quiet in operation. Direct or relay operation —with master control if desired. Pressure drops up to 2500 psi. Sizes to 14-inch. *Bulletin 477.*



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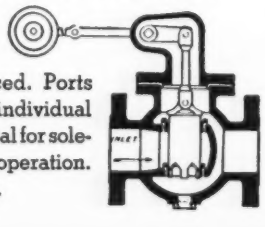

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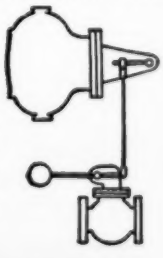

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Editorials

Dependency on Electricity

It takes a hurricane such as that which swept the Northeast Seaboard on November 25 to drive home to most people their widespread dependence upon electric energy for carrying on their normal everyday pursuits. Among the diverse inconveniences and hardships resulting from partial or complete suspension of electric service were stoppage or curtailment of electric railway service, both above and under ground, ferry service where docking facilities were dependent on electric power, telephones, street, shop and home lighting, heating with oil burners or stokers, electric hot-water heating, cooking by electricity, radio and television, not to mention a multitude of other electric appliances.

Had the storm occurred during the week, numerous business operations would also have suffered.

While many of the service stoppages were due to overhead distribution lines being down from fallen trees or poles, or cut off as a precautionary measure, underground distribution also suffered in some cases from inundation. The extent and periods of outage varied, of course, with the location of the affected area, ranging from a few hours to two or more days. Meanwhile, those affected were treated to a glimpse of living during the middle of the nineteenth century. For the most part the inconveniences were taken in their stride, as inevitable in an electric age where the annual per capita use of electricity reaches approximately 1650 kwhr. However, one may wonder as to how many stopped to think of the heroic efforts of the utility service crews in striving, under adverse and often dangerous conditions, to restore normal services as quickly as possible. These are the men to whom major credit is due.

Troubles from Burning Residual Oils

One of the best attended and most timely sessions at the A.S.M.E. Annual Meeting, from the operating man's standpoint, was that dealing with the burning of residual fuel oils in steam boilers. With the marked increase in fuel oil consumption by central stations and the influx of foreign oils during the past few years, difficulties from corrosion and plugging have been encountered. These have initiated several studies and resulted in a number of published papers on the subject. In general, the vanadium content of certain oils was believed to be chiefly responsible, although its action and that of certain other constituents was not definitely established.

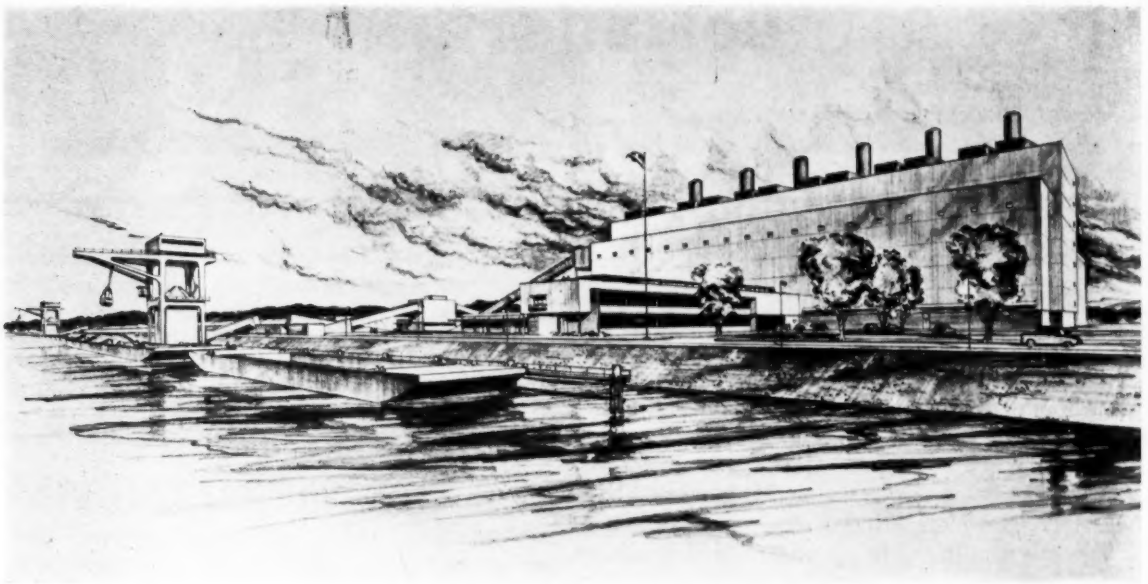
The survey presented at this session, and reported briefly elsewhere in these pages, was most exhaustive in that it brought together the operating experiences of practically all the oil-burning central stations, as well as the refineries, supplemented by the findings of several investigations. It would appear from this that the serious cases are not as widespread as might have been supposed; that other contents of the oil, notably sodium sulfate, are as responsible as vanadium pentoxide, and that trouble from plugging and hot-end corrosion is unlikely if tube temperatures are kept below 1100 F. Cold-end corrosion in the air heater may present a problem due to the sulfur, if the exit gas temperature is low. Here it is a matter of balancing a slight decrease in efficiency against the cost of washing and maintenance, as well as the residual oil price.

Engineering Manpower

One of the most important problems facing the engineering profession at the present time relates to the supply of engineering manpower. Several factors contribute to the anticipated shortage of engineers. Foremost is the international situation as reflected in military mobilization and defense production. But as far as continuing education of engineers is concerned, related factors are the pessimistic reports on the future need for engineers emanating from the Bureau of Labor Statistics and the fact that there are fewer persons now coming of college age because of the low birth rate during the depression of the 1930's. By implying that there will not be enough jobs for engineers and influencing school counselors to discourage high school students to enter engineering, one government agency is aggravating the engineering manpower problem at the same time that other government agencies—to say nothing of private industry—stand in need of more engineers.

The engineering profession through the Engineers Joint Council has been asked by the National Security Resources Board to suggest policies and methods which will insure the effective utilization of engineers for large-scale mobilization. An eighteen-man Engineering Manpower Commission composed of representatives of six engineering societies has been appointed with the responsibility of developing policies and procedures designed to secure the most effective use of engineering skills in industry and government during any future emergency and of taking necessary steps within the scope of the Engineers Joint Council to bring such policies and procedures into effect. The situation is complicated by the uncertainty of universal military training and expansion of R.O.T.C. in the colleges. Also, present policies of Selective Services have apparently led to much confusion concerning the future of engineering students.

The fundamental need is to use the limited reservoir of engineering manpower to its best advantage. It is to be hoped that the Engineering Manpower Commission will be able to set up and implement a policy which will forestall the waste of engineering skills that resulted from some of the induction procedures of World War II.



Architect's perspective of Johnsonville plant

Johnsonville Steam Plant of the TVA

A discussion of the design features and some of the reasons why certain conditions and designs were selected. The plant is laid out for six 125,000-kw units with throttle conditions of 1450 psi, 1000 F. The first unit is scheduled for operation in October 1951 and the others at two-month intervals thereafter.

By H. J. PETERSEN*

DURING the years following World War II the rapidly increasing demand for power in the Tennessee Valley area soon made it evident that an expansion program would have to be undertaken to prevent a critical shortage of power in the next few years. From July 1, 1948, to July 1, 1950, the average use of power jumped from 1,754,000 kw to 2,068,000 kw, an increase of 314,000 kw in two years. A study of this problem indicated that the quickest and most economical way to obtain this extra power was to firm up the Authority's secondary hydro power by erecting a steam power plant.

Accordingly, funds were requested from Congress for a steam plant of three units, each having a capability of 125,000 kw. These funds were approved in May 1949 and construction began immediately. In March 1950 one more unit of similar capacity was authorized, and during the fall of 1950 another two units were authorized, making the total installed capability 750,000 kw. The first unit is scheduled for operation in October 1951 with the remaining units following at approximately two-month intervals. When completed, the Johnsonville Steam Plant will be the second largest steam-electric plant in the world and will make an important and substantial contribution to the national defense program.

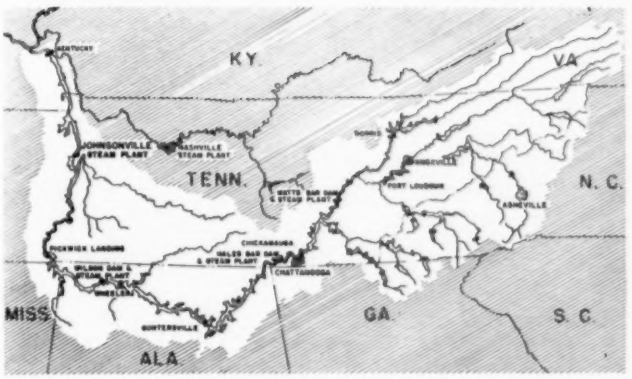
* Head mechanical engineer and chief of the mechanical design branch, the Tennessee Valley Authority, Knoxville, Tenn.

Site Selection

The site selected for the plant was chosen because of the advantages it offered in the way of fuel availability and transportation, cooling water supply, relation to the system load center, topography, transmission facilities, and several other factors. When it is realized that the six units will burn more than 300 tons of coal per hour and will use more than 650,000 gallons of cooling water per minute when operating at rated load, the importance of such factors is evident. Therefore, the site chosen, as most nearly satisfying the requirements for this plant, is in Western Tennessee on U. S. Highway No. 70 where it crosses the Tennessee River. Coal can be delivered at this site by barge, rail or truck.

Power House

An investigation was made regarding the merits of a semi-outdoor type of power house versus the conventional fully enclosed type. After considerable study it was decided that while it is recognized that the semi-outdoor type offers some saving in first cost, this could be minimized with a cheaper type of construction, and the operating conveniences of a closed power house need not be sacrificed. Accordingly, the superstructure walls are faced with aluminum siding, which has a very low erection cost, with a horizontal section of brick to relieve the monotony of the solid wall for architectural appearance.



Relation of Johnsonville to other plants of TVA

The walls of the turbine room and the office wing and service area are a combination of aluminum siding and brick and glass block.

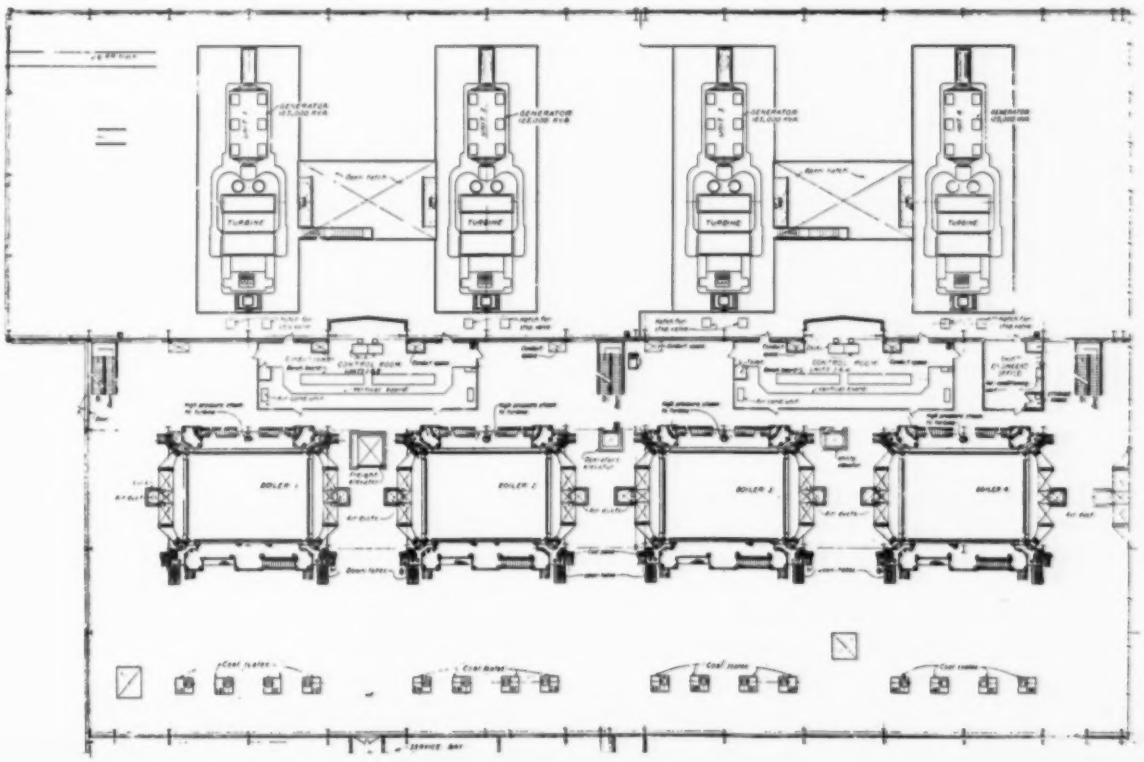
By close supervision of the design, waste space in the power house was eliminated in so far as possible, thus further reducing the advantage of a semi-outdoor type. The final figure of 19.6 cu ft per kilowatt for the power house proper compares favorably with other modern stations of this size. If all the shops, offices, storage rooms, etc., are included, this figure increases only to 21.2 cu ft per kilowatt.

Fly-Ash Dispersal

The tremendous quantities of coal which will be burned at Johnsonville would result in a very large emission of fly ash from the stacks unless preventive measures were adapted. Although the location is not near any large centers of population, it was recognized that some steps should be taken to eliminate as much of the fly-ash nuisance as possible. The mechanical fly-ash collectors which are being installed to protect the induced-draft fans from excessive erosion will eliminate most of the fly ash. Also provision has been made in the power house design for the future installation of electrostatic precipitators should they prove necessary. The stacks rise 50 ft above the power house roof, which makes their height 171 ft above grade. They also are designed so that an additional 100 ft can be added at any future time, for better dispersal, if necessary. Wind direction and velocity instruments will be installed on the stacks to aid in the air pollution studies.

Turbine-Generators

The turbines have a capability rating of 125,000 kw with a terminal pressure of $2^1/_2$ in. Hg and the steam conditions at the throttle are 1450 psi and 1000 F. The first four generators will have a capability of 125,000 kva at 0.5 lb hydrogen pressure and 143,750 kva at 15 lb hydrogen pressure. The last two generators are designed for a capability rating of 156,250 kva at 30 lb hydrogen pressure. The first four units will be single-shaft tandem-compound double-flow units, operating at 1800 rpm with generator voltage of 13,800. The last two will be triple-flow units operating at 3600 rpm with generator voltage of 18,000. At the time the first four units were purchased they were among the largest units combining these limits of capacity, temperature and pressure. By the time the last two units were purchased the major turbine builders had developed designs for 3600-rpm machines of this size, which partially accounts for the change in speed. Another factor is that the 3600-rpm machines cost from $400,000 to $500,000 less per unit. The 1800-



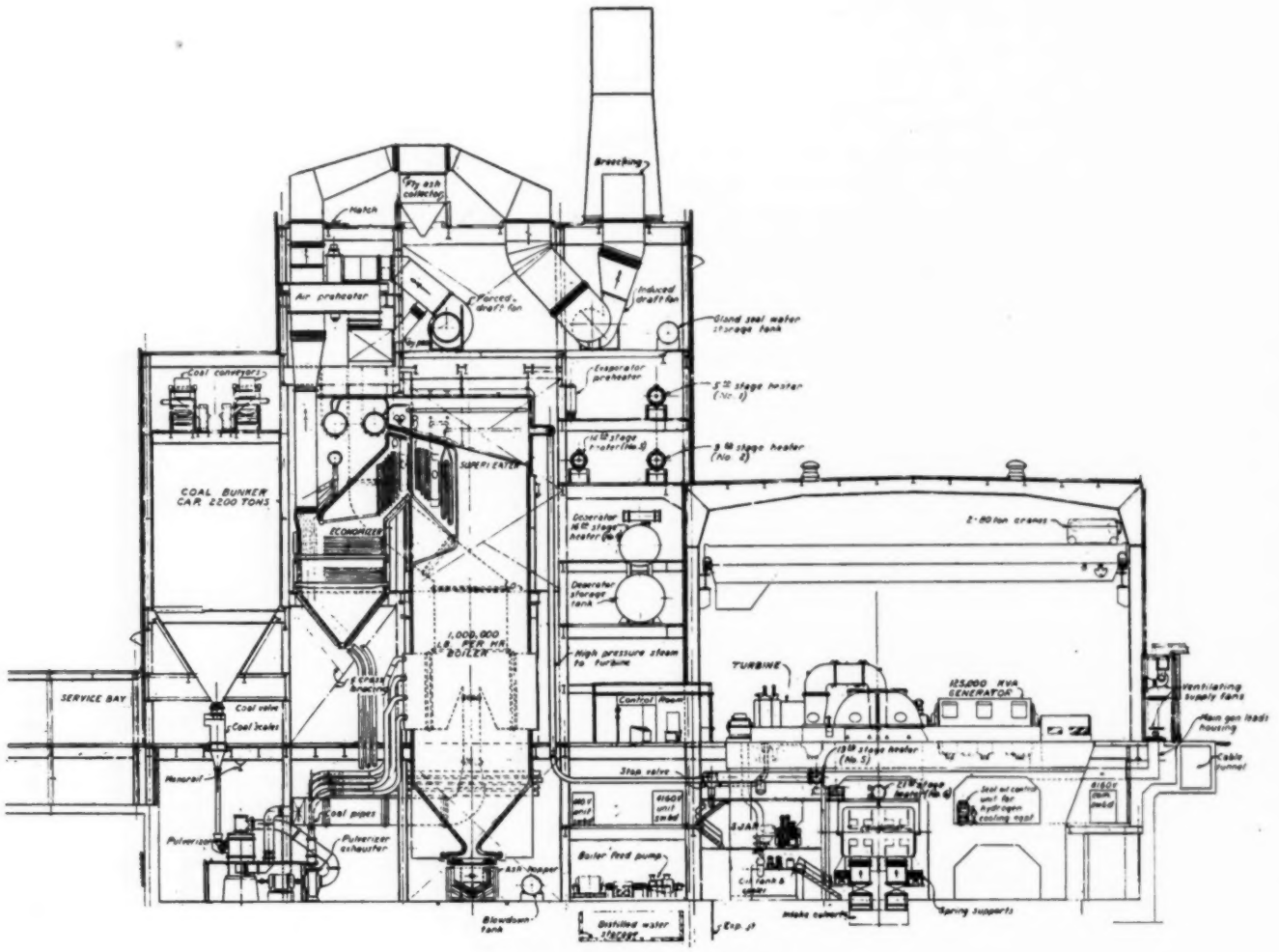
Station plan for first four units

rpm machines have higher efficiencies at lower back pressures, but the higher speed units have the better efficiencies at the higher back pressures with the change-over coming at about $1^1/_2$ in. Hg. A study of the cooling water temperatures and the load duration curve indicated that the units will operate approximately half the time on either side of $1^1/_2$-in. Hg back pressure.

Single-casing versus tandem-compound double-flow turbines was investigated. It was found that the savings of the double-flow unit due to its higher efficiency at the scheduled loadings would more than offset the appreciably lower cost of the single-casing unit. This, plus the fact that no single-casing units of the required capacity had been built at the time these units were purchased led to the choice of the double-flow turbines.

heat balances. Although one or two plants were being designed for 1050 F and/or a higher pressure, it was felt that these conditions, at that time, were still in the experimental stage and they were rejected in favor of the 1450-psi, 1000-F machines. Since that time the Authority is contemplating the use of 1800-psi, 1000-F turbines for future units at another plant.

The first four units (1800 rpm) will be equipped with moisture separators in the cross-over pipe to the low-pressure turbines. The turbine manufacturer guarantees that this device will remove 24,500 lb of moisture per hour at rated load from the steam at this point, resulting in a decrease in the turbine heat rate of 34 Btu at this load. This moisture will be drained from the separator to the lowest pressure heater, thus returning it to the heat



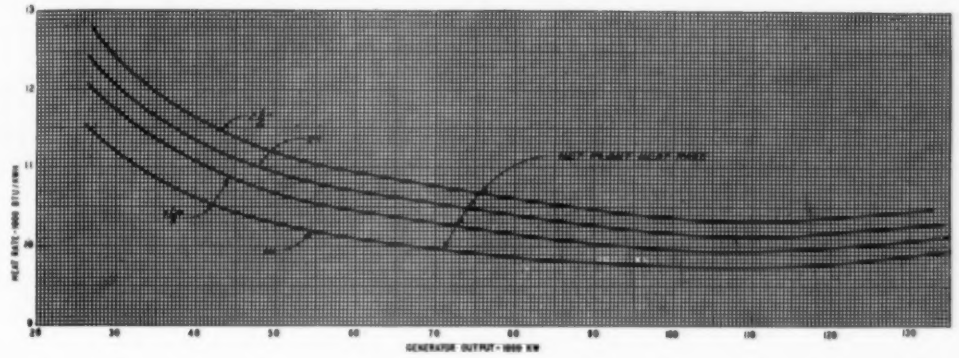
Sectional elevation of plant

Two sets of pressure-temperature conditions were investigated; namely, 1250 psi, 950 F and 1450 psi, 1000 F. At $1^1/_2$-in. Hg back pressure and rated load the gain in heat rate by going to the higher steam conditions is approximately 1.45 per cent for the temperature rise and approximately 1.0 per cent for the pressure rise, making a total gain of approximately 2.45 per cent. The economics of this gain in heat rate is very favorable, hence the higher pressure and temperature were adopted.

Use of 1050 F and some higher pressure than 1450 psi was also investigated, but not to the extent of running

cycle. The moisture reduction at the end-point because of the extractor is approximately from 15 per cent to 10.6 per cent which will eliminate much of the erosion on the last stage blades, thereby reducing maintenance. Use of a moisture extractor in the 3600-rpm machines is impractical because of the temperature and pressure conditions at this point.

The reheat cycle was investigated, especially for Units 5 and 6, but it was rejected because the low price of fuel ($0.18/MBtu) did not offer enough financial advantage to overcome anticipated extra complexities of control



Heat-rate curves

and maintenance. However, with fuel costs continuing to rise and with the added experience being gained in control and operation, the advantages of the reheat cycle continue to increase, and it is probable that the Authority will install reheat units in some future plants.

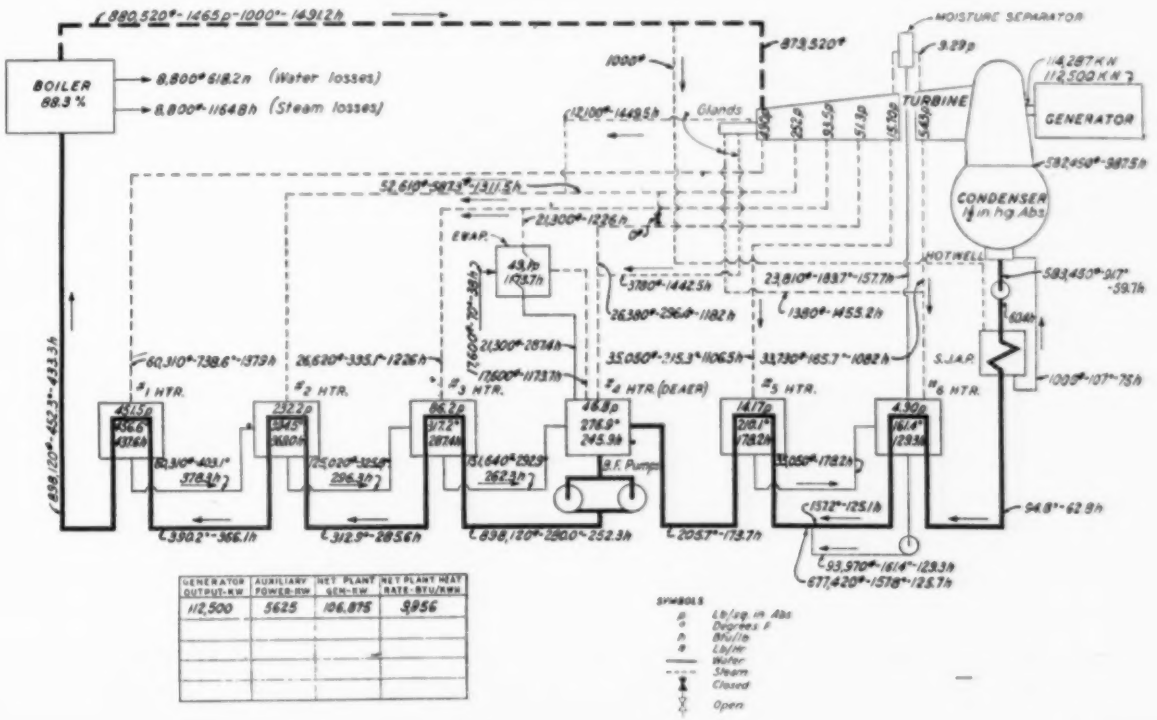
The maximum lift for the generator requires a 150-ton crane. However, two 80-ton cranes will be installed instead of one larger one, because it is felt that the slight extra cost of this arrangement is more than compensated for by the extra flexibility and availability of the two smaller cranes.

Heat Balance

The diagram here reproduced shows the heat balance at rated load and $1^1/_2$-in. Hg back pressure for the first four units. The calculated net plant heat rate of 9956 Btu per kwhr which includes 5 per cent station power, 2 per cent makeup, and 1 per cent of the throttle flow each for steam and water losses in the boiler, will make the Johnsonville Steam Plant one of the most efficient steam plants in the world. Inasmuch as experience at other plants indicates a makeup of less than 1 per cent, the actual net plant heat rate will be somewhat lower.

The number of feedwater heaters was investigated and it was found that six heaters gave the best economy. As the diagram shows, condensate pumps will pump through two low-pressure heaters, one of which will be located in the condenser neck (two in the case of Units 5 and 6), then into the deaerating heater, from which the boiler feed pumps will force the water through three high-pressure heaters to the economizer in the boiler. The deaerating heater has an effective storage capacity of 200,000 lb of condensate, which is equivalent to approximately twelve minutes of operation.

Closed heaters were chosen over open heaters because of their simpler piping and pumping arrangement. On the first four units the three high-pressure heaters are designed with internal subcoolers to reduce the drain temperature to within 15 deg of the incoming feedwater. This was more than justified in the heat rate, and, in addition, reduces the flashing in the drain line, thereby eliminating to some extent a usually troublesome maintenance item. On the feedwater side, all closed heaters are designed for a 5 deg total temperature difference; but when Units 5 and 6 were purchased, further study indicated that a lower drain T.T.D. could be justified and



Heat-balance diagram

the high-pressure heaters for these units are being designed for a drain T.T.D. of 10 deg. In addition, a subcooling section is being added to the second low-pressure heater. This addition was primarily to reduce the high amount of drain flash, since the two low-pressure heaters are located in the condenser neck, and it is impossible to design the cascaded drain line such as to avoid entirely the erosion of fittings.

Steam Generators

The steam generators will be of the dry-bottom type each with a continuous rating of 1,000,000 lb per hr and a three-hour rating of 1,100,000 lb per hr based on using West Kentucky coal. They are completely water walled and steam conditions at the superheater outlet are 1475 psi and 1003 F. Because of the large capacity of these units, a study was made to determine whether one or two boilers should serve each turbine-generator. The unit system of one steam generator per turbine was finally adopted because of the proved reliability of steam generators of this size, and also because of the large savings in first cost, maintenance and operating costs of the unit system. To this end, the furnace, superheater, economizer and all other components of the steam generating units were specified to be designed liberally with respect to water-cooled heat-absorbing area, heat release in the furnace, tube sizing and spacing, gas velocities entering the superheater, etc., in order that the slagging be kept at a minimum and the unit availability be kept as high as possible. The heat release in the furnace was held to 15,100 Btu per cu ft per hr and the heat available in Btu per sq ft of water-cooled flat projected furnace envelope is 99,200, both at rated load. The temperature of the gas leaving the furnace at this load will be 1940 F which is below the fusion temperature of the coal. It is felt that with these safeguards the Authority will be able to burn any coal found in this area with a minimum of slagging.

Firing is by pulverized coal with provision for future burning of gas. Four pulverizers are provided per furnace with any three capable of carrying rated load with normal coal. There are four vertically adjustable, tangential coal burners, four ignitors, and one oil burning torch at each corner of the furnace. The oil-burning torches have a slightly greater capacity than the minimum output from one coal pulverizer and will be used in starting up the boiler.

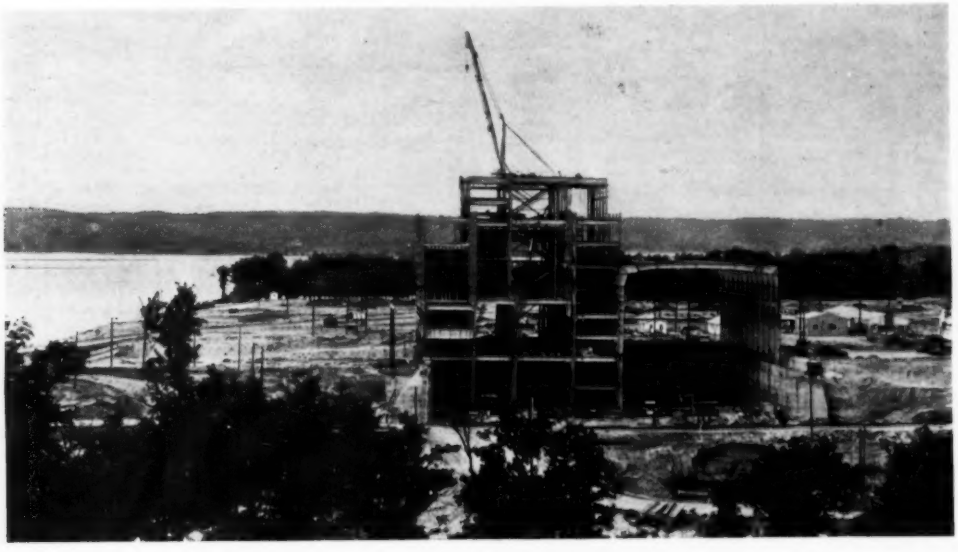
The economics of steam versus air soot blowers was investigated. The steam generators purchased have only three soot blowers on each side of the furnace at the entrance to the superheater section. This low consumption of soot-blowing medium would not justify the investment required of compressors, tanks, and piping for air soot blowing so a steam system was chosen. Provision is made in the economizer section and in the furnace for future soot blowers, if they should prove necessary. All soot blowing will be by the so-called automatic-sequential system where the pushing of one button automatically operates all soot blowers in their proper sequence.

Because of the height of the boiler drum it was found impractical to mirror drum level to the centralized control room. Accordingly, this level will be brought to the control room by a "Utiliscope," which is wired television. Furnace flame indication will be brought into the control room by mirroring glass cat's-eyes which are to be installed in the furnace doors.

Provision has been made in the circulating parts of the steam generator for acid cleaning.

The superheated steam will be maintained at constant temperature (1003 F) down to one-half load. The control of this temperature will be by automatic tilting of the burners and by desuperheating.

Regenerative-type basketed air preheaters will be used and the exit gas temperature (uncorrected for leakage) will be 307 F. Lower exit temperatures were considered, but were discarded because of the possibility that exists of fouling the air preheater elements when the lower temperatures approach the dew point of the exit gases. However, provision has been made in the heaters so that additional elements may be inserted in the future, if they prove desirable. These additional elements will lower the exit gas temperatures approximately 20 deg, gaining approximately one-half per cent in boiler efficiency. Provision also has been made for manually bypassing the air preheater during starting up and low-load operation to prevent slagging of the heater elements at these relatively low temperatures. If operation proves it necessary, this bypass can be converted to automatic control.



Construction view as of late September

Progress on boilers by mid-October

Condensers

The condensers are horizontal single-pass units, and each will condense 690,000 lb of steam per hour at 2 in. Hg with 79-F circulating water. They each have 70,000 sq ft of surface, are directly connected to the turbine exhaust, and are supported by springs which are anchored to the turbine foundation. A twin-element steam jet ejector will remove all non-condensable vapors.

The use of two-pass condensers was rejected because of excessive pumping costs and also because we shall have an unlimited supply of cooling water which is required for the single-pass design. No chlorination of condensing water will be provided for at present, but provision has been made for this feature in the future should it be required. Moreover, no reverse flow of circulating water for trash removal is provided because past experiences with plants on the Tennessee River have indicated that it was not needed. Racks and traveling screens are deemed sufficient to keep the condensers from clogging.

Each condenser will be served by two vertical mixed-flow circulating water pumps, each rated at 56,000 gpm at 21-ft head. They are located in the pumping station at the river's edge and pump through 78-in. diameter concrete pipes to the condensers. Under emergency conditions, one pump will operate the system with 85-F cooling water to produce 3 in. Hg back pressure at a throttle steam flow of 1,100,000 lb per hour. At this rating one unit will pump 74,000 gpm at 10-ft head due to the reduced friction loss in the circulating system at this lesser flow. All necessary valves and pumps will be controlled from a central control room in the pumping station.

Piping and Valves

All 1000-F main steam piping is forged and bored and conforms to the requirements of A.S.T.M. Specification A182–48T, except that the chemical composition will be in accordance with A.S.T.M. Specification A213–46, Symbol T-22, containing $2^1/_4$ per cent chromium and 1 per cent molybdenum, except that the carbon will be limited to 0.10 per cent maximum. Steel is specified to be silicon killed to minimize graphitization.

A scale model test was performed on the main steam piping. There are no loops in this piping and our calculations indicated that the stresses were close to the allowable limit. A model test confirmed this by indicating the maximum stress to be less than 300 lb per sq in. under the allowable limit. Thus, the use of the model test permitted us to eliminate loops in this heavy expensive piping. It is estimated that the savings because of the elimination of these loops amounts to $18,000 per unit.

There are no valves on the main steam line between the superheater outlet and the turbine stop valve. Venturi valves will be used in the boiler feed discharge lines. A cost analysis indicated that the extra pressure loss for this type valve was far outweighed by the saving in first cost. All 1500-lb valves have pressure-sealed bonnets.

Control Room

Throughout the whole design of this plant an effort was made to reduce the number of operators required. This is especially evident in the design of the control room where all the principal mechanical and electrical control functions (except switching) are centralized in one room. For example, each unit will be provided with an 80-point temperature indicator-recorder scanning device to record the temperatures of all main turbine-generator, draft fan, boiler feed pump and pulverizer bearings.

Each control room will serve two generating units. This arrangement called for some ingenuity of design because of the multiplicity of control piping and conduit concentrated at one point; however, it is felt that the result is worth the effort. Some investigation of a single control room for each boiler-generator combination was made, particularly with a view toward reducing the length of the control boards. It is probable that as the development of miniature instruments becomes more advanced that they may be used in future plants, thus reducing the size and length of the control boards.

Auxiliaries

No steam-driven auxiliaries will be used except the steam jet air pumps for the condensers. The numerous

incoming sources of power supply dictated the use of motor drives for all auxiliary equipment.

Calculations indicated that fluid drives were economical for the boiler feed pumps, but not for the mechanical draft fans. One of the major factors influencing fluid drives for the pumps was that we omitted the boiler feedwater regulating valve in the pump discharge line, thus eliminating pumping against the high-pressure drop across the regulating valve. The speed of the pump which regulates the feedwater flow is controlled by the fluid drive.

Three boiler feed pumps are provided for each boiler with any two capable of handling the rated load. These pumps are barrel-casing type and are rated 1209 gpm at 4770-ft head with 290-F water. They each have a shut-off head of 5505 ft, and the impellers are designed with a rising pressure characteristic which will prevent hunting with its consequent surging at the part-load operation. They operate under a net positive suction head of 66 feet.

The test block requirements of the forced-draft fans are 160,000 cu ft of air per minute against 12.5 in. water pressure and of the induced-draft fans are 250,000 cfm of gas against 14.75 in. water pressure. There are two of each per boiler, and the ratings established are such that a continuous output of approximately 600,000 lb per hr may be obtained from the boiler with only one forced-draft and one induced-draft fan operating. Speeds were limited to 900 rpm for the forced-draft fans and 600 rpm for the induced-draft fans. All fans are direct-connected and volume regulation is by means of inlet vanes and inlet dampers.

The general scheme of ventilation is for the incoming air to be blown in at the lower levels in both the boiler room and the turbine room. Additional outside air will be blown in at the heater area level to make these hot spots more comfortable. The floor areas and gratings are designed to make the inlet air for the forced-draft fans pass from the lower power house levels to the fan floor up along the walls of the boiler. In this way the air will pick up a good deal of heat from the radiation from the boiler thereby increasing its temperature before it reaches the forced-draft fan inlet. Since each 38 deg rise in this air increases the efficiency of the boiler approximately one per cent, the advantage of this arrangement becomes obvious. The whole power house is under a slight positive pressure from the supply fans, which helps prevent infiltration of dust and dirt.

All the main auxiliaries which will have a direct influence on the plant output, such as draft fans, feedwater pumps, condensate pumps, condenser circulating water pumps and pulverizers, were investigated as to their capacities during times of reduced frequency and/or voltage. It was found that each generating unit will be able to maintain an output of 125,000 kw with frequency reduced to 55.2 cycles at 100 per cent voltage, or with a frequency of 56.3 cycles at 83 per cent voltage.

The capacity of the coal bunkers was fixed at 2200 tons per unit. This capacity was decided upon because it is enough coal to run the units at rated capacity over a week end, thus eliminating any coal handling activities over that period. The coal yard has sufficient area to store 1,000,000 tons of coal. Because of the large size of the storage area, mobile coal-handling equipment will be used.

The furnace ash, fly ash and pyrites will be removed by a jet system, rather than by pumping. This method of handling the ash was selected because the Authority believes it involves less maintenance and operation. The fly-ash system will be controlled by an automatic sequential arrangement whereby each hopper is automatically unloaded in its proper sequence.

Plant service air will be obtained from three 660-cfm, two-stage, air compressors operating at 100 psi. Air for the various control instruments will be obtained from a separate system of two single-stage compressors, each rated 440 cfm at 100 psi. These latter machines will have non-lubricated carbon rings in the cylinders to prevent oil leakage past the pistons where it might reach the instruments.

A completely automatic sodium-zeolite system is being provided for treating the makeup water delivered to the evaporator, and a secondary chemical system will be provided for feeding sulfite, phosphate and caustic soda to the feedwater as required.

All engineering and construction work on this plant is under the direction of C. E. Blee, chief engineer; R. A. Monroe, chief design engineer; G. K. Leonard, chief construction engineer; and J. S. Bowman, chief water control planning engineer. All mechanical design is under the supervision of the writer.

JOHNSONVILLE STEAM PLANT—PRINCIPAL EQUIPMENT FOR SIX GENERATING UNITS

ITEMS	CONTRACTORS
Turbine-generators (Units 1, 2, 3 and 4)	General Electric Co.
Turbine-generators (Units 5 and 6)	Westinghouse Electric Corp.
Steam generators	Combustion Engineering-Superheater, Inc.
Soot blowers	Diamond Power Specialty Corp.
Condensers	Ingersoll-Rand Co.
Feedwater heaters	The Lummus Co.
Deaerating heaters	Elliott Co.
Evaporators	Foster Wheeler Corp.
Boiler feedwater pumps	Worthington Pump and Machinery Corp.
Condenser circulating water pumps	Ingersoll-Rand Co.
Combustion controls and control boards	Bailey Meter Co.
Piping contract	National Valve and Mfg. Co.
Ash-handling system	United Conveyor Corp.
Draft Fans	American Blower Corp.
Fly-ash collectors	Western Precipitation Corp.
Boiler room coal scales	Richardson Scale Co.
Coal valves	Columbus Conveyor Co.
Zeolite softeners	Hungerford and Terry, Inc.
Secondary chemical feed equipment	Proportioneers, Inc.
Station service air compressors	Pennsylvania Pump and Compressor Co.
Control air compressors	Bury Compressor Co.
Valves—high pressure	Chapman Valve Mfg. Co.
Safety valves	Foster Engineering Co.
Butterfly valves	Henry Pratt Co.
Condenser water conduits (78-in. diameter)	Lock-Joint Pipe Co.
Turbine room cranes	Judson Pacific Murphy Corp.
Traveling water screens	Chain Belt Co.
Coal-handling equipment	Link-Belt Co.
Powerhouse structural steel	Ingalls Iron Works
Stacks	Birmingham Tank Co.
Aluminum siding and steel roof decking	H. H. Robertson Co.
Main Transformers	Westinghouse Electric Corp. and General Electric Co.
Main switchboard	Allis-Chalmers Mfg. Co.
Auxiliary switchboard	Westinghouse Electric Corp.
Auxiliary switchboard	I.T.E. Circuit Breaker Co.
Station service transformers	Westinghouse Electric Corp. and General Electric Co.
Oil circuit-breakers	Westinghouse Electric Corp.

A.S.M.E. ANNUAL MEETING

WITH an attendance of approximately 5000 the Seventh-first Annual Meeting of the American Society of Mechanical Engineers at the Statler Hotel, New York, November 26–December 1, comprised 83 sessions and over 200 technical papers, in addition to numerous special luncheon talks and social events. The diversified program included sessions on Fuels, Power, Heat Transfer, Applied Mechanics, Fluid Meters, Production, Hydraulics, Gas Turbines, Management, Oil and Gas Power, Railroads, Instruments and Regulators, Wood, Materials Handling, Aviation, Machine Design, Rubber and Plastics, Safety, Petroleum, Lubrication, Textiles, Process Industries, Metals Engineering and Rockets. However, only certain fuels and power papers are abstracted in the following report of the meeting.

New A.S.M.E. President

The incoming president of the Society is **J. Calvin Brown,** Los Angeles engineer and patent attorney, who succeeds **James D. Cunningham** of Chicago.

Central Station Cost Study

G. R. Milne of the Consolidated Edison Co. of New York, Inc., gave the results of cost studies made to determine the most economical size and type of boiler and turbine-generator for a new station on his Company's system in a paper entitled "Basic Cost Study for a Generating Station." The following are some of the basic assumptions that were made:

1. Feedwater temperature of 450 F.
2. Six stages of feedwater heating (a supplementary study was made comparing the economy of five, six, seven and eight stages; also a comparison of the cost of a single boiler feed pump versus that of a combination of booster pumps ahead of the boiler feed pump).
3. 1-in. Hg back pressure with 45 F circulating water.
4. Motor-driven auxiliaries used throughout.
5. Auxiliary power requirements assumed as 7 per cent of gross output.
6. Study limited to maximum steam temperatures of 1050 F.
7. Fuel cost of 40 cents per million Btu.
8. Initial annual loading of 5000 hr at full load; 1500 hr at $^3/_4$ load and 1000 hr at $^1/_2$ load.

In comparing units of 80, 110 and 160-megawatt maximum capability it was found that the largest units held an economic advantage. Similarly, the single boiler arrangement showed a favorable cost differential ranging from $3^1/_2$ to $7^1/_2$ per cent by comparison to two boilers per unit. Based on a single-boiler-per-turbine arrangement, a cross-compound unit was found to be more economical than a tandem compound, and in addition the former had a quadruple exhaust providing a higher overload capacity. The most economical non-reheat cycle evaluated was found to be 1450 psig, 1050 F, while the most economical reheat cycle, 1800 psig, 1000 F, 1000 F, had an evaluated cost $4^1/_2$ per cent under the non-reheat cycle just noted. The arrangement finally selected was a 160-megawatt, 3600/3600-rpm cross-compound unit with a single boiler per turbine operating on the reheat cycle at 1800 psig, 1000 F, 1000 F.

An investigation was also made to determine the number of feedwater heaters. Based on fuel at 40 cents per million Btu and 6 deg F terminal difference in closed heaters, the cycle using seven stages of heating with closed heaters both above and below the deaerator is justified. The cycle selected has a theoretical net heat rate of 9335 Btu per kwhr, excluding certain losses, and actual net station heat rate approximating 9700 Btu per kwhr.

Discussion

The selection of 1000 F for both primary and reheat steam temperatures was believed by one engineer to ease the problem from the standpoint of materials, since ferritic steels may be used. Already columbium, one of the constituents for alloy steels in higher temperature service, has been restricted. There was some question as to why the cross-compound turbine was found to be more economical than a tandem-compound unit. The subject of preferential loading of the most efficient plant during early years of operation indicated a divergence of opinion, one discusser saying that it cannot be justified and another advocating this type of operation.

Furnace Performance Factors

The third phase* of the investigations of the Special Research Committee on Furnace Performance Factors

* The first phase of this investigation was carried out at the Tidd Station of The Ohio Power Co. and has been published in Trans. ASME, vol. 70, July 1948, pp. 553–619; the second series of tests took place at the Paddy's Run Station of the Louisville Gas & Electric Co. and was reported at the 1949 ASME Annual Meeting in paper Nos. 49-A-42, 49-A-117 and 49-A-118.

dealing with furnace heat absorption when burning pulverized coal was reported in two parts. These reports are based on a series of thirteen tests made in June 1949 on a single drum B. & W. boiler rated at 500,000 lb of steam per hour at 1350 psig and 950 F at the superheater outlet. This unit which is located at the Willow Island Station of the Monongahela Power Company, Willow Island, W. Va., has a water-cooled dry-bottom furnace that is fired through the roof with six multi-tip inter-tube burners. The tests were made to determine the effect on furnace heat absorption of variations in load, excess air and the arrangement of burners in service.

Part I, "Furnace Heat Absorption Efficiency As Shown By Temperature and Composition of Gases Leaving the Furnace," was prepared by **James W. Myers** and **Richard C. Corey** of the Combustion Research Section of the Bureau of Mines. The furnace heat absorption was determined as the difference between the net heat input and the heat losses comprising the sensible heat in the products of combustion and radiation and convection losses from the furnace casing. During the thirteen tests the gas temperature at the furnace outlet varied considerably with position. Generally, the highest temperature occurred on the right side of the furnace outlet and the lowest on the left when symmetrical burners were in operation. With other burner arrangements, the maximum temperature occurred between the center and left side, and the minimum usually was found between the center and right side. In several tests, particularly those with all burners in service, very low temperatures were observed near the division wall, which was ascribed to low gas velocities or eddy currents. Disregarding these low points, the spread in the temperature of exit gases varied from 200 to 460 F. It was concluded that the temperature distribution patterns have a complex relationship with distribution of fuel and air to the burners, the velocity and path of the gas between the burners and the furnace outlet, and the location and extent of ash deposits on the walls.

Good agreement was noted, except for one test, between the furnace heat absorption calculated from heat-balance data and the heat required for generation of steam. Approximately 90 per cent of the evaporation occurs within the furnace, excluding the screen. The maximum corrected furnace heat-absorption efficiency was 56.6 per cent at half load, when operating with two mills and 24 per cent excess air. The lowest efficiency, 42.4 per cent, was obtained at full load with 24 per cent excess air and with all burners in service. The furnace heat-absorption efficiency decreased with an increase of excess air in all cases, the decrease being more pronounced at higher loads. Although the evidence is not entirely conclusive, it would appear that the effect of excess air on the heat-absorption efficiency is independent of the location of burners in operation. With all other conditions held constant, the heat-absorption efficiency decreased with increased values of net heat available.

The study shows the feasibility of a relatively simple correlation of furnace heat absorption with the temperature of the gases at the furnace outlet. Although this correlation may be used to evaluate the effect of such factors as flame area and emissivity, it is an empirical treatment. There is a need to understand more fully how such fundamental variables as furnace geometry, firing method, burner location, and fuel and air distribution control the flame shape, ash deposits and furnace-outlet temperature.

Part II "Variation in Heat Absorption As Shown By Measurement of Surface Temperature of Exposed Side of Furnace Tubes" was presented by **F. G. Ely** and **N. H. Twyman** of the Research and Development Dept. of The Babcock & Wilcox Co. It is concerned with supplementary and independent measurements of furnace heat absorption obtained from special thermocouples installed in furnace wall tubes. Since the furnace comprises a major portion of steam generating surface and thereby serves to reduce the temperature of combustion products to acceptable values for entrance to the superheater, the proportioning of heat-absorbing surface of the furnace and superheater becomes a critical design function. Deviations in the functioning of either of these components must be accounted for quantitatively and provision made for positive compensation in the daily operation of the unit.

Supplementary tests were made using a sampling arrangement of special thermocouples installed in the furnace wall tubes in such a manner that the temperature drop through the tube metal could be evaluated, at least relatively, in terms of heat flux. A total of 124 furnace-wall-tube thermocouples were installed during the erection of the boiler and were connected by external lead wires to a Leeds & Northrup Speedomax Recorder equipped with a special selector switchbank which permitted scanning the entire group in approximately 24-minute cycles. The pattern of placement was intended to provide a sampling which would measure and show the distribution of the heat absorption rate.

The tests disclosed that the effects of ash materially distort any simple comparison that might be drawn from their limited number. However, these generalizations seem justified:

1. Increased load increases the maximum rate of heat absorption and markedly increases absorption of the ash-free lower portions of walls and hopper section.
2. The effect of increase or decrease in excess air is obscure but may similarly increase the proportion of heat absorbed in the lower part of the furnace.
3. Use of all burners transfers more duty to the upper part of the furnace, while the opposite effect is indicated for an unbalanced burner arrangement.

Prevention of Embrittlement Cracking

Some twenty-five years ago intercrystalline cracking of boiler steel, as caused by the building up of concentrated caustic in contact with stressed metal, was thought to be inhibitable by maintaining a definite sulfate-alkalinity ratio in the boiler water. Therefore, these recommended ratios were incorporated in the ASME Boiler Code in 1926. Subsequently, however, it was demonstrated that such treatment was uncertain, particularly at higher pressures; but research pointed to the effectiveness of tannin, lignin and sodium nitrate.

In this connection, an embrittlement detector had been developed at the Bureau of Mines Boiler Water

Research Section at College Park, Md. This detector was widely described in the technical press at the time and has since been in use at many utility and industrial power plants. In brief, it is a device attached to a boiler in such a way that partial evaporation and concentration of the boiler water takes place on the stressed surface of a test specimen which forms part of an especially designed seam.

A. A. Berk, of the Bureau of Mines, in a paper on "The Prevention of Embrittlement Cracking," summarized the results of some 2000 tests obtained with 600 detectors in 500 boiler plants as reported during 1949, as well as 500 tests on locomotive boilers. The results showed the effectiveness of sodium nitrate, tannin and zero-caustic treatments. Nitrate and quebracho are inhibitors of intercrystalline corrosion in hot, concentrated caustic solutions; and the zero-caustic treatment (also called the "coordinated phosphate" or "captive alkalinity" method) prevents the formation of concentrated solutions of caustic.

Because of the interest for a quarter of a century in the sulfate-alkalinity ratios, data for pressures to 250 psi were re-examined. In 57 tests where the recommended sulfate-carbonate ratios were satisfied, caustic soda was present and nitrate or tannin was not present in significant amounts. Cracking resulted in 39 of these tests which corresponded approximately to the frequency of failure in the group of tests representing no treatment. In contrast, there were no failures where the concentration of free caustic was zero, fewer than one per cent where the water was treated with nitrate, and fewer than 8 per cent where quebracho or tannin treatment was used.

Twenty-six cases of cracking of stationary boilers had been investigated by the author during the period 1942-1949; of these, twenty-four were definitely due to embrittlement. In six of the plants the boiler drums were welded and in the others riveted. Cracks were found in butt straps, drum metal, tube seats and tube ligaments. In no instance was nitrate or a tannin type inhibitor present in concentrations shown by embrittlement-detector tests sufficient to prevent cracking. The effectiveness of the sulfate-alkalinity ratios could not be accurately proved or disproved, however, inasmuch as none of the plants had complete data to show that the ratios had always been maintained. Nevertheless, five of these plants (four at pressures under 400 psi) maintained the prescribed ratios at the time of failure.

Discussion

In discussing Mr. Berk's paper **R. C. Bardwell,** of the Chesapeake & Ohio Railroad, told of the first cases of caustic embrittlement encountered in locomotives of that railroad as far back as 1912 and of an epidemic of intercrystalline cracking around 1930. In most of these cases high sulfate-alkalinity ratios were being employed. Detectors were then employed and with some waters the test metal specimens shattered in 15 days. However, since treatment with sodium nitrate has been adopted, such troubles have ceased. This treatment is now recommended by the American Railway Engineering Association. Criticism was directed by several discussers at retention of the sulfate-alkalinity ratio in the A.S.M.E. Boiler Operating Code. It was contended that, among the several methods of inhibiting embrittlement, sodium nitrate is the most effective and superior to zero alkalinity.

Humidification of Combustion Air

"Fireside Deposits on Steam Generators Minimized Through Humidification of Combustion Air" was the title of a paper prepared by **Paul Murphy, Jr., John D. Piper** and **Chester R. Schmansky** of The Detroit Edison Co. The work reported is said to be the first instance in which combustion air has been humidified for the specific purpose of reducing the formation of high-temperature deposits in large stoker-fired steam generators and for which proof is given that humidification accomplishes that purpose.

Chemical analyses of deposits removed early in 1949 from the superheaters of stoker-fired units at the Delray Station showed that these deposits could be classified as being of the alkali-matrix type. It has been reported that sodium, potassium and lithium compounds volatilize or are carried in flames from the fuel bed and condense upon cooler surfaces, where they react with sulfur trioxide to form sticky semi-fluid sulfates, bisulfates and pyrosulfates. After reviewing theories concerning the formation of alkali-matrix deposits, a decision was made to investigate the possibility of eliminating the volatilization of sodium and potassium compounds. One procedure is to add a reactant that will render the product less volatile than the original material; by adding moisture an endothermic water-gas reaction may take place in the fuel bed. The heat thus absorbed should be recoverable when the products of the reaction burn.

For many years it had been known that superheater deposits formed more rapidly in winter than in summer at the Delray Station. The amount of water vapor per hour entering the fuel bed with combustion air was computed from U. S. Weather Bureau data for 1948 and 1949, and it was found that there was striking correlation, especially for the latter year, with periods of high humidity coinciding with periods of low stack-gas temperature and high efficiency. Therefore it was decided to make a test run in which a total input of 7000 lb per hr of moisture were introduced for a steaming rate of 325,000 lb per hr, or 16.4 lb of moisture per 1000 lb dry air. Flexible control was provided so that the amount of moisture, which was added as saturated steam, could be adjusted each hour to compensate for changes in the absolute humidity of the outdoor air. Before the test began on December 3, 1949, the external heating surfaces were given a routine scraping and alkali-water washing, and the economizer and air heater surfaces were fairly well cleaned, although the less accessible superheater surfaces held the usual residual blue-gray deposits.

A test was run for 133 days with humidification. During this period the stack-gas temperature increased but 10 deg F, while the boiler-outlet gas temperature rose approximately 50 deg F in the first 60 days of operation and then remained essentially constant. Through this period the steam generator was capable of steaming 400,000 lb per hr, and it was observed that there was less deposit on the front rows of superheater

tubes than would have been the case in 30 to 50 days without humidification. The economizer was remarkably clean; the water walls and boiler tubes remained free of white deposits which normally accumulate; the air heater was in the same condition at the end of the 133-day test as is generally found after 30 to 50 days without humidification.

According to information available to date, the humidification requirements will average 1.3 per cent annually, with a peak of 2 per cent during the coldest part of the winter. With what is already known concerning humidification it would appear that this method, by keeping heating surfaces cleaner, will improve average efficiency at least enough to compensate for the cost of its use, thereby leaving a distinct gain through better availability and lower maintenance.

Discussion

Great interest was expressed in the humidification experiments of The Detroit Edison Company, and already a number of utilities are humidifying air for stoker-fired installations. Mention was made of an English plant in which flue gas was recirculated and introduced into the fuel bed to accomplish much the same result. In plants already having low makeup requirements and limited water treatment facilities, humidification may introduce some problems by requiring an additional $1^1/_2$ per cent makeup. There was general agreement that The Detroit Edison Company had performed a real service in making available detailed reports on the humidification tests.

Coal Handling

The Materials Handling Division sponsored two papers on coal handling, the first of which by **Frank W. Lovett** of Link-Belt Co. was entitled "Methods of Handling Coal at Today's Power Plants." Among factors that should be considered in selecting a coal-handling system are present means of receiving coal and possibilities of future changes, amount of storage space for stacking out and reclaiming, provision for increasing capacity of the coal-handling system at the time of plant expansions, size and location of plant, and type of coal used.

Several trends in power plant design affect the design of coal-handling systems. Greatly increased hourly rates are required to unload and handle coal because individual stations of today have greater generating capacity and require dependable performance in assuring continuous electrical output. The conveyor designer encounters many problems as a result of poorer grades of coals which contain wet fines, sometimes with considerable clay, and are difficult to handle in hoppers, chutes and bunkers. Because of the uncertainty of coal supply due to potential mine strikes and transportation delays, increasingly large reserve storage is required, though there is compensation in purchasing coal for future use at favorable prices. Higher labor costs and the difficulty of obtaining men to work at unloading stations when cleaner, less hazardous jobs are available must be considered. The desire for better housekeeping requires that dust be controlled at unloading stations and transfer points.

For current central stations coal-handling systems will vary in cost between $3 and $5 per kilowatt of installed capacity, depending upon the capacity, type and scope of operation of equipment used. Plants handling 300 tons or more per hour and having rail delivery are finding increasing use for the rotary car dumper. This has the ability to unload any type or kind of coal in the largest or smallest type of open-top gondola car by the simple expedient of turning it upside down. Some dumpers have been designed for 40 or more cars per hour.

Unloading hoppers are usually housed to prevent accumulation of coal and ice, particularly in colder climates. In areas having long freezing seasons it is a good practice to provide thawing pits. Belt feeders are increasing in popularity because of their simplicity of design, readiness to be made dust-tight, and easy maintenance. Belt conveyors are used almost exclusively in coal-handling systems of 150 tons per hour or greater capacity. In modern stations single-length belts are handling from 1000 to 2400 tons per hour, and improvements in belt construction have made possible the increase of length between centers to as much as 11,000 feet.

Bulldozers and carryalls are now being used quite extensively for storing and reclaiming coal. They can be operated over rough terrain for extended periods without excessive operating costs or maintenance.

A unique method for handling the clam-shell bucket of the coal unloader at the Philips Power Station of the Duquesne Light Company was described in a paper by **E. M. Hays** of the Engineering Works Division of the Dravo Corporation. Entitled "Versatile Coal Handling Installation for Public Utility Power Station," the paper enumerated features which contribute to low operating cost and high production rate.

Operating on alternating current, the unloader has a rope reeving arrangement which eliminates clutches and brakes on hoisting arms, minimizes spillage and simplifies operation by eliminating much of the personal judgment heretofore required. The station is located at Wireton, Pennsylvania, on the Ohio River, and coal is obtained by barge. There are two 10-hp single-drum winches which operate in tandem to move the barge past the unloader at a normal pulling speed of 26 ft per min. These winches have electric, full-magnetic controllers with master switch operation located in the coal unloader operator's cab.

The coal bucket is a four-rope, fleet-through geared hinge, corner-bar bucket having a normal capacity of $6^1/_2$ tons. A counterweight which counterbalances the total weight of the bucket plus one-third of the material at full load moves opposite to the direction of travel of the bucket. When hoisting a fully loaded bucket the load on the motor is equal to two-thirds of the material load in the bucket, and when lowering the empty bucket the load on the bucket is a hoisting load resulting from the moving counterweight equivalent to one-third of the material load. With a positive hoisting load for bucket lowering, a simple reversing electromagnetic controller provides smooth slow-down speed.

The unloader is able to make a round trip consisting of digging a full bucket of coal from the barge, transport-

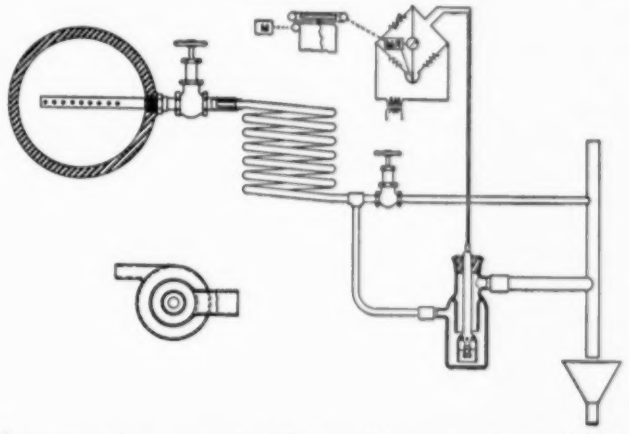
ing it to a point over the hopper, and returning empty to the barge in 33 sec. In conjunction with the barge mover and an efficient operator, the unloader is capable of handling approximately a net coal volume of 500 tons per hour.

Low cost of operation is anticipated because of the following:

1. Equalization of rope tension in hoisting the bucket, assuring longer rope life.
2. Counterweighting which results in a smaller hoisting horsepower requirement and good speed control in lowering the bucket.
3. Spillage minimized due to positive closing before hoisting.
4. Elimination of much personal judgment through automatic bucket closing and rope equalization.

Determination of Dissolved Solids in Steam

Sheppard T. Powell, consulting chemical engineer, and **I. G. McChesney,** of Rochester Gas & Electric Corp., described an apparatus that was developed to simplify the determination of dissolved solids in steam by electrical conductivity measurement while preventing contamination of the sample by gas or by impurities picked up in the sampling or testing apparatus. Because dissolved gases often combine chemically with the condensate it was necessary to take steps to prevent



Apparatus for measuring the specific conductivity of high-pressure steam samples

initial contamination of the condensate as it is formed in the sampling and measuring system. This is accomplished by drawing off the steam at high velocity in such a manner that the exposed surfaces of the condensate particles are thoroughly scrubbed by steam passing through the sampling tube. The sketch shows the general arrangement of the apparatus.

The apparatus is designed for use when sampling steam in a pressure range from somewhat above atmospheric to extremely high pressures and the discharge is at atmospheric pressure. It has been tested over a period of nearly two years and has been operated for a period of eighteen months with only minor adjustments. Moreover, it is capable of recording solids in the steam well below one-half part per million, the accuracy having been checked against meticulous evaporation of a number of large samples.

Operation with Hot-Lime-Zeolite Process

In a paper describing pretreatment by this means of boiler makeup for maximum hardness, silica and bicarbonate reduction, Messrs. **L. F. Wirth,** of National Aluminate Corp., and **W. S. Butler,** of Dow Chemical Company, related experience at the Ludington plant of the last-mentioned company over a period of more than eight months.

With makeup taken from the Pere Marquette River, this plant, containing two 225,000-lb per hr, 425-psi boilers, had originally employed the hot lime-soda-phosphate system at an operating temperature of 230 F. Subsequent changes in the plant product requiring the direct usage of 40,000 to 50,000 lb of steam per hour in process brought the makeup requirements beyond the capacity of the existing softening system, and consideration had to be given to selection of a new system.

Decision was in favor of trying hot styrene-type resinous-exchange material, which recent pilot plant studies had shown to be applicable to secondary softening following the hot lime soda process. This was tried for a period of 41 days and resulted in total hardness reduction from 167 ppm as $CaCO_3$ in the raw water to 1.8 ppm in the secondary effluent, but silica reduction was negligible and the average CO_2 content of the steam was 5 ppm. Turbidity of the primary softener effluent averaged 40 ppm as SiO_2.

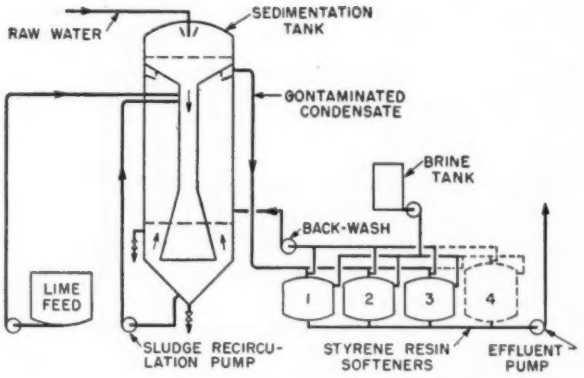
Next it was decided to determine the effect of the addition of sodium aluminate to the primary softener, followed by the hot styrene resin exchange. This had the effect of further reducing the final total hardness to 0.6 ppm, the silica to 0.8 ppm and the turbidity to 4 ppm, as SiO_2. The CO_2 in the steam averaged 5 ppm.

This combination was then modified by incorporating a sludge blanket and recirculation of 5 per cent of the sludge with the result that turbidity of the effluent of the primary softener was reduced to 2 ppm and the carbon dioxide in the steam to 3 ppm.

Finally, the primary treatment was changed to hot lime-sodium aluminate, with sludge blanket, followed by the hot styrene resin exchange. The results of 51 days' operation gave an average total hardness reduction from 167 ppm as $CaCO_3$ in the primary influent to 0.5 ppm in the secondary effluent, of which 0.1 ppm was magnesium; silica reduction from 3 ppm to 0.5 ppm; turbidity averaged 0.7 ppm; and CO_2 in the boiler steam 1 ppm.

The conclusions from this eight-month study under actual operating conditions were as follows:

1. Hardness of the secondary softener effluent of a hot lime-aluminate-styrene resin softener can be reduced to 0.4 ppm, of which 0.1 ppm is magnesium.
2. With sludge recirculation, silica can be reduced to 0.3 ppm as SiO_2.
3. Sodium aluminate fed together with the lime results in turbidity of 1 ppm or less in the influent to the secondary softener.



Two-stage hot-process system sedimentation plus ion exchange

4. When lime and sodium aluminate alone are used for the primary treatment the CO_2 content of the steam can be maintained at 1 ppm, which should be helpful in eliminating magnetic iron oxide deposits.

The accompanying sketch shows the projected layout of the softening system installed at this plant. While improved operation of the ion-exchange units might result from inclusion of filters between the primary and secondary stages, space limitations preclude their installation.

Discussion

A question was raised as to the advisability and safety of omitting filters between the settling tank and the zeolite bed in the installation described. There may be some danger of break-through at unpredictable times which filters may help to prevent. Several discussers mentioned the possibility that the addition of sodium aluminate to the primary softener may lead to the formation of complex aluminate compounds in the feedwater. The use of styrene-type resins to treat high-temperature cooling water which would otherwise be discarded was proposed.

Expanded Tube Joints

The making of expanded tube joints in tube sheets of unfired pressure vessels was discussed in a paper by **F. F. Fisher** and **G. J. Brown,** both of The Detroit Edison Company. The authors reviewed present-day practice of rolling-in such tubes and presented information gained from installing, retubing, testing and repairing many types of heat-exchangers.

They recommended that the optimum degree of expanding be determined by tests conducted in advance of actual rolling operations and that the information so obtained be recorded and made available to others. Preference is given to the automatic relay-operated technique for uniform tube rolling.

It was proposed that tube joints be shortened to a minimum; and that with thick tube sheets, the unrolled portion of the joint be sealed by lightly rolling a short section of tube, preferably with automatic tube rolling devices. The same method was preferred when rolling tubes to specific design instructions, because manual rolling-in does not produce specified results with certainty. Non-ferrous tubes rolled into steel tube sheets with a joint length of $2^1/_2$ in. have proved satisfactory.

With reference to tube-hole clearance, the authors expressed the belief that this should be kept to a minimum and that 0.005 to 0.007 in., or less than half that of some conventional practice, is ample for heat-exchangers using seamless drawn tubing, also for many large heaters and condensers. The drilling of smaller than conventional holes in the support plates of heaters and condensers provides an effective means for elimination or reduction of tube vibration and consequent tube wear.

As to the finish to be given tube holes, it was pointed out that rolled joints are primarily friction joints and that their holding strength depends upon the pressure and roughness between the contacting surfaces. On the other hand, pressure tightness is best obtained by use of smooth contact surfaces. For example, relatively rough tube holes can be used in heat-exchanger work if the tubes are much softer than the tube sheet. But if the tube material is hard, greater movement is produced between the contacting surfaces, and the axial flow of tube metal may shear or smooth off any roughness of the tube hole. For this reason the tube holes in boiler construction are reamed cylindrical and smooth and the reinforcing grooves are placed near the zone of minimum movement of the tube metal.

In order to bring out the full strength of a joint without undue distortion or damage to the tube sheets and headers, the tube metal should be softer than that of the tube sheets or headers.

Finally, particular attention should be paid to the sequence of rolling-in tubes in order to reduce to a minimum, or to eliminate entirely, stresses caused by the elongation incident to tube expanding.

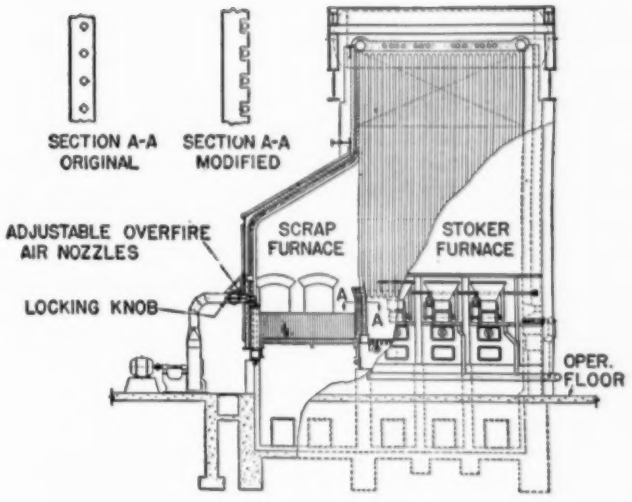
Combination Spreader Stoker and Waste Fuel Furnaces

The Sloane-Blabon Corporation, Philadelphia, manufactures felt-base floor covering from which there is much scrap in the form of large sheets and strips. For many years this scrap presented a disposal problem. Periodically it was hauled to a dump and at other times it was burned under a boiler.

The product contains about 50 per cent wood pulp, 14 per cent rag stock and 36 per cent newsprint, the mixture being heavily impregnated with asphalt. The volatile runs very high and the heating value ranges from 12,000 to 14,000 Btu per pound.

Present methods of burning by means of a two-stage furnace in combination with coal were described in a paper by **F. C. Messaros** of American Engineering Company.

The boiler is of the two-drum, bent-tube type and, as shown in the accompanying illustration, has a primary furnace for burning the scrap and a secondary furnace to which coal is fired by means of a three-unit spreader stoker. The coal-burning furnace is completely water cooled, but the scrap furnace has water cooling only on the side wall and roof with refractory walls at front and rear. A 4-ft refractory and water-cooled curtain wall provides partial separation of the two furnaces.



Sectional front elevation through primary and secondary furnaces

Scrap is charged manually into the primary furnace, but coal is fed to the spreader units by a conveyor. Attempts to hog the scrap were abandoned because of the many bolts, nuts, etc., present.

To provide the necessary turbulence ten overfire air nozzles are located in the side wall above the grate of the primary furnace. These jets as well as the undergrate supply employ 300-F air.

The unit is equipped with a cinder and fly-ash collecting system.

Cleaning Turbine Lubricating Systems

A paper on "Recommended Practices for the Cleaning of Turbine Lubricating Systems After Service," as prepared by the Joint A.S.T.M.-A.S.M.E. Committee on Turbine Lubrication, was presented by **F. E. Rosenstiehl** of The Texas Company. Stressing the necessity for cooperation between the turbine builder, the operator, and the oil supplier, it included specific instructions for proper cleaning.

Although adequate purification during circulation, through use of oil-purifying equipment, will go far to prevent build-up of insoluble foreign matter in the system, periodic inspections are essential to show whether proper maintenance practices are being followed and to reveal any contamination of the oil by impurities and foreign matter that may have found their way into the system. When a turbine is placed in service, a close watch should be kept until operating conditions have stabilized; and when a new turbine is taken down for complete general inspection within the first year, as generally recommended by the builder, there is excellent opportunity to examine the oiling system for evidence of deposits, corrosion, or abnormal wear. It is also common practice to take frequent samples of the oil for visual inspection to detect the presence of water, emulsions or suspended matter.

A marked change in the oil temperature differential across the cooler with no change in water flow or water temperature may indicate excessive build-up of deposits on either the oil or water side of the cooler or both. Hot water or steam washing, or petroleum flushing oil, are usually employed for cleaning the oil side of coolers. When using hot water, boiler feed at above 180 F is forced through at high velocity. Bearing pedestals and oil reservoirs are cleaned by directing a stream of hot water against the surface. However, clean dry air should be applied immediately thereafter and, since steam or hot water will remove protective oily films, the system should be protected as quickly as possible with rust-inhibiting turbine oil or flushing oil to prevent rusting.

On the other hand, in some instances where a lightly sludged unit cannot be taken out of service for a time sufficient for thorough cleaning prior to an oil change, continuous bypass circulation of the oil, through a clay filter, has been employed to remove the contaminating products. But as the clay will also remove the inhibitors, it is suggested that the oil supplier be consulted before employing this procedure.

Effect of Vanadium When Burning Residual Oils

In view of the many cases reported of slagging and corrosion encountered in boilers firing heavy residual fuel oils, particularly those containing appreciable percentages of vanadium, the Petroleum and Chemical Panel of the Joint A.S.M.E.-A.S.T.M. Committee on Effect of Temperature on Properties of Metals undertook a comprehensive survey of the subject. This included a large number of petroleum companies and those power generating stations known to be burning such oil, as well as major equipment manufacturers. The numerous replies and an analysis of the findings were presented in a group of papers by **E. F. Tibbetts** of The Lummus Company, **O. L. Wood, Jr.,** of General Electric Company, **D. Douglass** of Hartford Electric Light Company, and **V. F. Estcourt** of Pacific Gas & Electric Company.

The evidence submitted, while noting many difficulties with slagging and corrosion at elevated temperatures, nevertheless indicated that the majority of fuel oil consumers are not encountering serious difficulties, regardless of whether domestic or foreign oil is being burned. It is believed that although high vanadium oil ashes are the most troublesome, residual oils containing vanadium can be burned in most installations without difficulty if precautions are taken to assure good combustion conditions, through proper heating and atomization, and if the metal temperatures are kept below the melting temperature of the ash. The following points were emphasized as having important bearing:

1. Vanadium pentoxide itself is extremely corrosive in the molten state and is sufficiently volatile to be corrosive in the vapor state; but its principal effect is believed to be that it lowers the melting point of the already corrosive alkali sulfate ash.

2. Vanadium oxide is an active catalyst which is employed in the manufacture of sulfuric acid, and the assumption is that it catalyzes the formation of SO_3 from SO_2 which, in turn, will combine with solid or volatile sodium salts to form sodium sulfate.

3. Corrosion is attributed to vanadium-sulfate attack on protective oxide coatings of heat-resistant

steels. In one case in which the V_2O_5 comprises about 29 per cent of the ash, the corrosion of superheater supports and spacer bars was severe but there was very little attack on the tubes.

4. It is suggested that where temperatures are high and design does not permit radiant heating only, such as is the case in a gas turbine or where tube spacing cannot be increased, as in marine boilers, the only complete solution is the use of an additive to produce an ash having a higher melting point.

5. Marine boilers have been known to slag more quickly when the fuel has been contaminated with sea water with resultant sodium in the ash. However, such slag is largely water soluble.

6. The committee offers the opinion that, although certain residual oils containing appreciable amounts of vanadium are more troublesome in critical applications, the consumption of these fuels in noncritical applications will continue to greatly exceed that by the critical applications. Hence, it would be uneconomic for the oil refiner to attempt to change present practices where residual oils, as marketed, are blends of refinery runs of mixed crude charge stocks. Therefore, the committee believes it would be a serious mistake for a consumer to assume that such fuels can be supplied to specifications that restrict the source of crude to the refinery or to require special handling and storage.

Finally, if a simple conclusion can be drawn, it is that oil-fired furnaces and boilers must be designed with a full understanding of the problems involved, that the flow of flue gases containing oil ash must avoid, in so far as possible, contact with metal surfaces, and that all fuel oil must be atomized as completely as possible at all times, with combustion completed at the burner and no flame impingement on any metal surface. Cold end condensate corrosion can be avoided only by maintaining metal temperatures above the dewpoint of furnace gases and higher stack temperatures or recirculation of air in preheaters must be used if corrosion is encountered. The presence of higher percentages of vanadium in oil ash deposits will definitely catalyze the formation of sulfur trioxide which will, in turn, raise dewpoint temperature and thus initiate corrosion in furnaces where corrosion has not been encountered when low vanadium oils are fired.

Discussion

Many prepared discussions were presented. One summarized the investigations being conducted at Battelle Memorial Institute for the Hartford Electric Light Company toward developing suitable protective coatings to the steel and additives to the oil. Of the coatings thus far tried, both aluminum and chrome iron appear to offer some promise. The problem at Hartford, however, is somewhat special because the tube metal temperatures in the mercury boiler run higher than is usual with steam.

There appeared to be general agreement that all residual fuel oils are to some extent corrosive; that even where the vanadium content is low, an appreciable sulfur content is likely to cause corrosion in the cold end of the unit; that little trouble need be expected with tube temperatures below 1100 F, except in the case of hanger supports and tube spacers, unless suitably cooled and baffled; that no corrosion will occur below the melting point of the ash; and that vanadium is only one of the contributing factors, with sodium sulfate equally or more corrosive.

Another discusser reviewed experience at Sewaren Station employing 1050 F steam temperature. Here severe attack on hangers and supports had been overcome by water cooling, but there had been no appreciable plugging. However, cold-end corrosion and plugging of the air heaters had been encountered and necessitated washing with caustic, the frequency of such washing varying with the sulfur and vanadium content in the oil.

Review of Air Pollution Prevention

J. F. Barkley, of the U. S. Bureau of Mines, reviewed the history of smoke abatement ordinances dating back to 1876 in St. Louis, followed by Chicago in 1881, and widespread legislation in many cities about the turn of the century, with subsequent attention being directed to the general subject of atmospheric pollution from all sources. He summarized the difficulties of the situation as follows:

"After about a century of city air-pollution-prevention problems in this country, half of which has included considerable activity, the question naturally arises as to why better progress has not been made. Similar problems have been solved essentially as far as contaminants in city water, milk, food and drugs are concerned.

"Various reasons have been advanced as to why air pollution interest has waxed and waned. City politics, lack of funds, organizational difficulties, the general bigness of the problem, the countless sources and points of production of contaminants, the economic impossibilities of stopping the emission of contaminants, and lack of continued public interest all have been cited with good justification. Campaigns started by public spirited men, women, and organizations can always entrain followers for a time, but a campaign can only last so long, and the followers become interested in something else. . . . It is up to members of the medical profession to do their part toward better living by establishing needed facts about city air pollution that will impress themselves and then the general public."

Role of Aluminum in Graphitization

A paper by **A. M. Hall** and **E. E. Fletcher,** both of Battelle Memorial Institute, reported the results of an investigation directed toward the part played by aluminum in the breakdown of iron carbide in plain carbon steels into iron and graphite at temperatures below the critical point of the steel. The problem was approached by extracting the carbides from several plain carbon steels which had been deoxidized with different amounts of aluminum and had different known degrees of susceptibility to graphitization; then to examine and analyze the extracted carbides with particular attention to the amount and form of the aluminum contained therein. By comparing the aluminum thus found with that in the original steel, data were obtained on the rôle which that element appears to play in the graphitization process.

The results indicated that the difference between a graphitization-resistant and a graphitization-susceptible plain carbon steel is one of degree and not of kind. They cannot be divided into two groups—those whose carbon phase is stable and those whose carbon phase is unstable. Rather, all plain carbon steels are metastable, but to varying degrees. Although the readily graphitizable steels are least stable and the resistant ones most stable, all tend ultimately to be converted from iron and iron carbide to iron and graphite.

It was concluded that in order to promote graphitization the aluminum is either in solid solution in the ferrite matrix, or else fixes the nitrogen. The results further suggested that any aluminum that might be associated with the carbide phase is not influential in determining the degree of susceptibility to graphite formation.

Piping Failure

A. W. Rankin and **W. A. Reich** of the General Electric Co. presented a "Report on Split Steam Lead at New Orleans" based on a failure at the Industrial Canal Station of New Orleans Public Service, Inc., on June 16, 1949. The piping had been in service for approximately nine months, turbine throttle conditions being 1250 psig, 950 F. One end of the split was at a weld between the steam lead and a small forged stub intermediate between the stop valve and the steam lead, and the other end was approximately 30 in. downstream in the steam lead. There was no weld or detectable change in material or wall thickness at this latter end of the split.

The split section of the steam lead was cut out and returned to the manufacturer for an investigation of the cause of failure. The following procedures were carried out: X-ray and magnetic particle test, dimensional checks, physical tests, chemical analysis, macroscopic examination, microscopic examination, study of weld X-ray films. From the investigation the following major conclusions were established:

1. The subject pipe was cracked to within approximately $^1/_8$ in. of the outside surface prior to being placed in service.
2. The remaining approximately $^1/_8$ in. of wall failed either by rupture as a result of the long time at the service temperature of this installation or by a longitudinal tear initiated by such a long-time rupture in service at a particular point of the remaining wall.
3. The initial and major portion of this fracture, which is the inner $^5/_8$ in. of wall for the entire length of the split, took place at a relatively low temperature, and is a cleavage fracture characteristic of a failure below the charpy transition temperature of a material.
4. The cleavage fracture was produced some time between removal of the pipe from the cooling table in the pipe manufacturer's shop and the start of processing in the pipe fabricator's shop. During this latter processing, the fracture surfaces were oxidized when the pipe was heat-treated to produce the desired high-temperature properties. It is the opinion of the authors that the most likely point at which this cleavage failure was produced was during the cold straightening operations prior to the final cropping of the pipe, although definite evidence to substantiate this opinion is not available.

Ferritic Piping for High Temperatures

"High-Temperature Properties of a Ferritic Steam-Piping Steel" was the title of a paper by **A. W. Rankin** and **W. A. Reich** of the General Electric Co. Current maximum steam temperature levels of 1000 and 1050 F push the more common ferritic steels, with their customary heat treatments, to a point where heavy walls are required to maintain satisfactory margins on the creep and rupture strengths. Although austenitic steels may be used, material costs increase and fabricating and operating difficulties peculiar to the metallurgy of these steels may arise. Much is to be gained, therefore, if a stronger ferritic steel can be found for turbine shells, steam leads and station piping.

Molybdenum-vanadium steam leads have been in service at 950 F and 1000 F since 1948 and, in general, have performed satisfactorily with respect to fabrication, welding and service operation. There was one service failure at the Industrial Canal Station of the New Orleans Public Service, Inc., but it has been established that a crack almost completely through the turbine lead existed prior to fabrication, as noted in a companion paper by the same authors.

Testing Boiler Materials

J. B. Romer, of The Babcock & Wilcox Co., and **H. D. Newell,** of the B. & W. Tube Co., outlined the high-temperature metals testing procedures employed by their organizations in evaluating steels for high-temperature boiler operation. Present practices in their newly installed testing laboratory are to run both creep and rupture tests on important metals for periods of 10,000 hr or more. This length of time generally permits phase changes or alterations of structure to become complete and thereby lessens errors in extrapolation when securing data for 100,000 hours.

Superior alloy tubing materials for superheaters are required with steam temperatures of 1050 F and beyond with corresponding metal temperatures of 1200 to 1400 F in order to withstand oxidation and have long life at these temperatures. Under present Boiler Code regulations austenitic stainless alloys are limited to low working stresses due to their low strength under prolonged exposure to these temperatures. This results in very heavy tubing and greater temperature differential across the wall of the tube from the gas to the steam side. Development work is now under way on superior alloy materials which have at least equivalent resistance toward oxidation (compared to presently used austenitic stainless steels) and which lend themselves to production into tubing and pipe and to common practices of boiler fabrication.

Gas Turbine Regenerator

A. L. London and **W. M. Kays** of Stanford University in a paper entitled "The Liquid-Coupled Indirect-Transfer Regenerator for Gas Turbine Plants" analyzed the advantages and disadvantages of that type regenerator with respect to the conventional direct-transfer type. The indirect system consists of two units, one a hot-gas-

to-coupling-liquid exchanger, and the other a coupling-liquid-to-compressed-air heater, together with the necessary circulation system for the coupling liquid. A pumped liquid is employed to convey the thermal energy picked up in the hot-stream exchanger, where the gas is being cooled, to the cold-stream exchanger, where the compressed air is heated.

Compared to a single direct-type exchanger, the liquid-coupled indirect-type regenerator has the following advantages:

(1) The gas and air flow stream frontal areas may be shaped independently of one another.

(2) A considerable simplification of air ducting and header construction results because it is not necessary to bring the cold air over to the turbine exhaust stack and then back to the combustion chambers.

(3) If extended transfer surfaces are used to obtain compactness, it is only necessary to have fins on one side of the surface.

(4) Use of a multiplicity of smaller units may simplify manufacture, cleaning and servicing, and reduce the stress problems arising from thermal expansions.

(5) Closer approach to counter-flow characteristics can be realized without suffering a penalty in shape.

The liquid-coupled indirect-type regenerator has the following disadvantages:

(1) The requirement of a "good" liquid heat transfer medium for coupling the hot and cold exchanger units.

(2) An increase on the order of 5 to 10 per cent in total heat transfer area.

(3) A somewhat larger and heavier shell structure requirement.

(4) The addition of a flow circuit for the circulation of the coupling liquid.

To date no satisfactory liquid heat transfer medium is in common use, although there is promise in current work with liquid metals. A coupling liquid should have (1) a freezing point below 40 F, (2) a boiling point above 1000 F for moderate pressures, (3) low density and viscosity and high thermal conductivity, (4) a high heat transfer coefficient on the order of 2000 Btu per hr per sq ft per deg F for moderate flow velocities, (5) chemical stability, and (6) ease of handling in pumps and piping systems.

High Temperature in Marine Service

Lester M. Goldsmith, of the Atlantic Refining Company, described some of the engineering features of a 30,000-ton supertanker, the *S.S. Atlantic Seaman,* which is the first ship using 1020 F steam. The heat balance is based on four bleed stages from the main turbine, and the feedwater is heated to a calculated final temperature of 415 F. Using 18,500 Btu fuel oil this heat balance arrangement gives a predicted economy of 0.491 lb per shaft horsepower hour for normal running conditions. During a 24-hr period under ballast conditions on the maiden voyage of the ship, the fuel economy was found to be 0.489 lb per shaft horsepower hour with the condenser vacuum corrected to the design value of 28.5 in.

Boilers are of C. E. single-drum, water-tube sectional-header type and are rated at 65,000 lb per hr at 650 psig, 1020 F or 78,000 lb per hr at 625 psig, 1020 F. Superheat control is provided by means of a desuperheating coil located in the drum and arranged on an automatically controlled bypass ahead of the third pass of the four-pass superheater. Each of the two boilers is equipped with four double-nozzle wide-range oil burners incorporating a small central oil tip spraying through a larger outer one. A three-way cock permits the use of either or both of the tips and provides a 9-to-1 range without the necessity of pulling burners. Three constant-speed forced-draft fans are installed, of which two are for normal operation.

Air heaters are of two-pass design on the air side, provided with bypass dampers for use under low load or standby conditions. Air-puff soot blowers operating at 200 psig are arranged to operate automatically and continuously on a three-hour cycle for the two boilers.

The main propulsion unit consists of a cross-compound steam turbine with double reduction gear, a two-pass condenser with divided water box and an attached 700-kw auxiliary generator. The high-pressure turbine is of the impulse-reaction type, and the low-pressure turbine of the single-flow reaction type. There are two six-stage, 350-gpm boiler feed pumps, each driven by a 250-hp turbine supplied with steam at full boiler temperature and pressure. The exhaust steam from these turbines is used in the deaerator for feedwater heating.

Trends in Fuel Supply

Discussing "Changing Patterns of Fuel Supply," **James Boyd,** Director of the U. S. Bureau of Mines told those attending the Fuels Luncheon on Thursday that while coal in 1920 supplied 78 per cent of our heat and energy demand, by the end of 1949 this constituted less than 40 per cent. This was despite the fact that, except in periods of stoppage of supply, the amount of coal burned had remained fairly stable, the increase in demands having been supplied largely by oil and gas; for during this period the former increased from 15 to nearly 37 per cent and the latter from 4 to over 19 per cent. Since World War II the trend toward use of oil and natural gas has been accelerated by the construction of many long distance pipe lines.

Liquefied petroleum gases used for heating and other household purposes in rural areas now constitute a major petroleum product, while expansion in the use of diesels has greatly increased the demand for light oils. However, the largest amount of petroleum continues to be consumed by our forty-four million motor vehicles.

Production of crude oil in the United States has increased one-third since 1941, but during the intervening period the production of liquids from natural gas has almost doubled and petroleum imports have tripled. Although Venezuela is our leading source of foreign oil, the Middle East has supplied much in recent years. Discovery and development of major petroleum reserves in Western Canada have been of great strategic importance since 1947.

The total demand for oil and oil products during 1950 is expected to exceed 2.4 billion barrels, representing a gain of 9 per cent over 1949.

Indications that the present decade may witness a maximum in domestic petroleum production, followed by a decline, have been responsible for increased atten-

tion being given to the synthetic production of petroleum and certain of its products. Mr. Boyd then reviewed what the Bureau of Mines has been doing along this line.

Burning Petroleum Coke on Spreaders

Otto de Lorenzi of Combustion Engineering-Superheater, Inc., reported on tests conducted at his company's East Chicago plant in the burning of petroleum coke on a spreader stoker under a 25,000-lb per hr two-drum boiler with dumping grates. Colored motion pictures were shown of the fuel bed and furnace under various conditions.

There are large accumulations of petroleum coke at the West Coast refineries which make its use as boiler fuel most desirable, but in the Middle West and certain other sections of the country the industrial demands for use in various products are such as to make it command a higher price than coal.

Runs were made on two shipments of coke from different far western refineries, the characteristics of which differed somewhat. These were as follows:

Moisture	4.06	3.38
Ash	0.84	0.64
Volatile	12.04	11.77
Fixed Carbon	83.06	84.21
Sulfur	3.47	1.0
Btu/lb	14,413	15,040

Although it was found possible to burn 2 in. size with a sufficient percentage of undersize, $^3/_4$ in. was preferable. Because of the low ash content of the coke the fuel bed was very thin at the front end of the grate, but somewhat thicker at the rear. There was little suspension burning and both fuel distribution and excess air were found most important. The pictures showed, after a brief starting-up period, excellent flame conditions without smoke from the stack.

Post-College Training

Under the sponsorship of the Junior Committee a symposium was presented on "A Plan for the First Five Years After Graduation." This symposium was largely based on a report of the same title prepared by the Committee on Professional Guidance of the Engineers Council for Professional Development.

Karl B. McEachron, Jr., of the General Electric Company urged young engineers to recognize that they have obligations to their communities as well as to themselves and their families. Community relations are important because more time is spent in the community than on the job.

Prof. H. L. Solberg of Purdue University gave information on the history and current status of engineering registration and told of some of the things that the young engineer might do as a part of his post-college training. He cautioned that professional development does not stop with the attainment of legal registration. The attitude of employers toward engineering registration varies from complete indifference to a requirement that every man holding an engineering title must be registered. The young engineer should consider whether lack of registration may discriminate against his further promotion and whether or not he may at some time hold a position that will require him to be registered. With the widening requirements for examinations he should also seek to get registered as soon as possible, rather than to wait until much has been forgotten about the engineering principles studied in college.

J. C. McKeon of Westinghouse Electric Corp. pointed to the responsibility of the engineering profession to provide adequate educational opportunities for the employed engineer. This must be paralleled by professional growth on the part of the young engineer if he is to grasp fully the many opportunities open in both the technical and management fields. A self-development program is an important part of professional growth and should include informal as well as part-time formal education encompassing business and the humanities as well as technical subjects. Industries must not only encourage the development of their young engineers but must also work with the colleges and engineering societies in providing adequate educational opportunities.

"Non-Technical Reading" was the topic of a stimulating paper by **Prof. Weller Embler,** of the Cooper Union, who examined the reasons for reading and found these: (1) because one feels compelled to read, (2) because it is the thing to do, (3) for entertainment, (4) for knowledge or information, and (5) to change one's mind by meeting an intellectual challenge. The speaker suggested that an active reading pattern for the engineering graduate might begin by selecting what one wants to read instead of what he thinks should be read. This reading should be directed by making a simple list and it should then be supported with allied materials and researches. Next the reader should talk about what he has read with a sympathetic friend, and finally he should read with a purpose toward a definite end.

Fuel Engineering Education

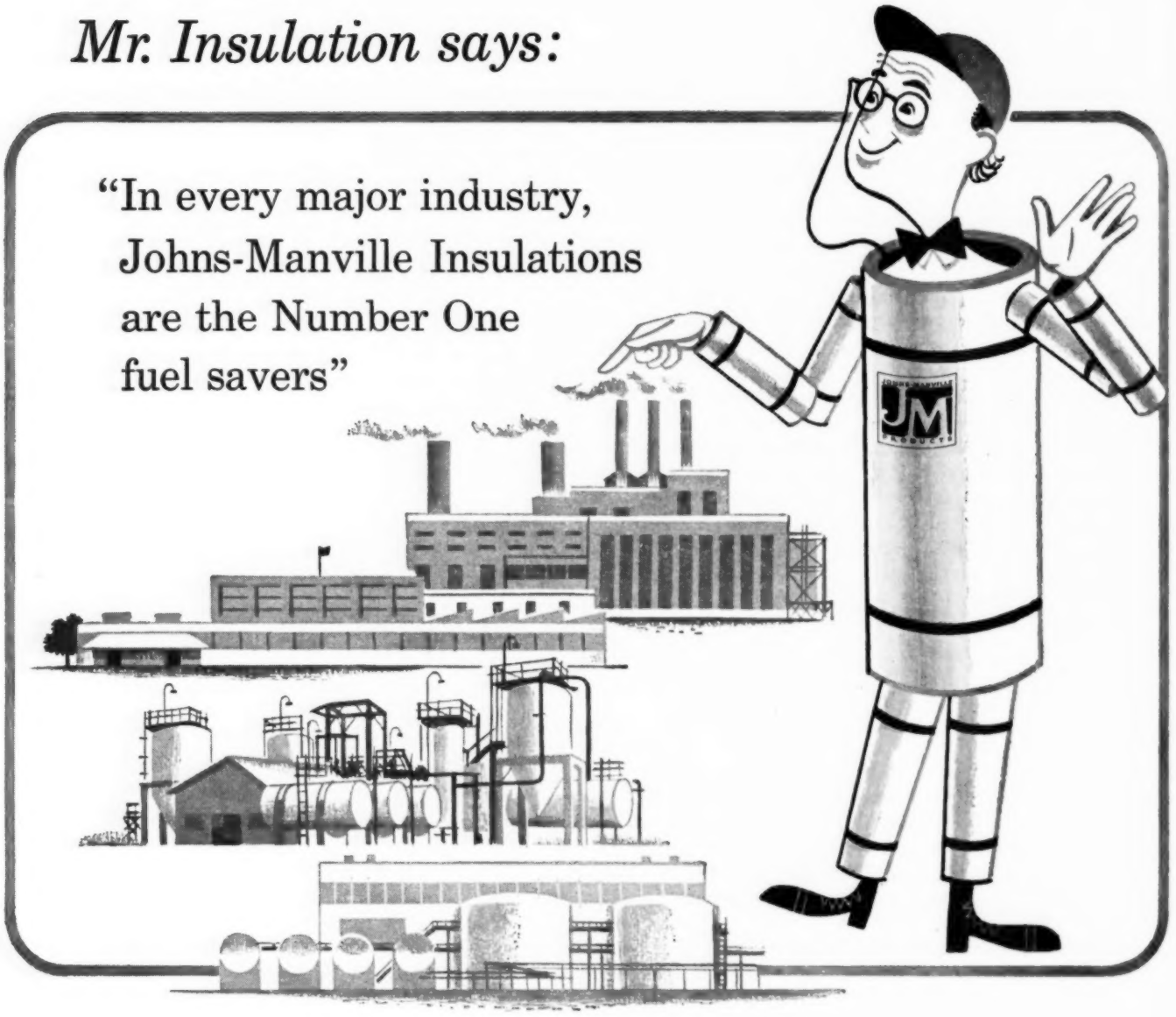
The Fuels Division sponsored a symposium on Fuel Engineering Education which represented composite views of colleges and industry concerning desirable theoretical and on-the-job training.

In discussing "What the Engineering Schools Should Teach About Fuels and Fuel Utilization," **Dean A. A. Potter,** of Purdue University, noted that the 1949 report of the Engineering Research Council of the American Society for Engineering Education listed 248 projects on such problems as coal combustion, cleaning, handling, hydrogenation, pulverizing, coke manufacture, oil production, oil shale processing, petroleum recovery and peat. He recommended that in all engineering curricula fuels should be studied as a part of a required heat-power course during the sophomore or junior year.

Elective courses in fuels and fuel utilization are desirable for senior and graduate students, and in a few engineering colleges it may be desirable to set up advanced programs in fuel technology to cover more extensively coal petrography, chemical constitution, carbonization, synthesis of liquid fuels and fuel equipment

(Continued on page 66)

Mr. Insulation says:



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New Central Station Cost Figures

LAST year, it may be recalled, the Federal Power Commission issued its first Annual Supplement to its previously published study on "Steam-Electric Plant Construction Costs and Annual Production Expenses, 1938–1947." This supplement gave the 1948 results for the 200 plants previously covered, plus those for 19 new plants. A second supplement dealing with 1949 figures has just been issued, together with those for 26 new stations that went into service late in 1948 and in 1949. The total installed capacity of these 245 plants represent approximately 69 per cent of the total electric utility steam generating capacity in the United States, and their 1949 net generation was 77 per cent of that for all such plants in the nation.

Figures are not yet available for the numerous stations that have gone into service during the present year; presumably they will become available late in 1951 and some should reflect still greater overall economy due to employment of reheat in several cases.

Various data are given for each of the plants listed, but of particular interest are such items as initial cost per kilowatt of installed capacity, net station heat rate and total production expense, as well as fuel and labor expense per kilowatt-hour.

Inasmuch as many of the plants listed were built during the pre-war period and subsequently extended, the combined initial unit costs mean little when compared with those of new plants. Commenting on this, the report observes that the 26 new plants listed reflect 75 to 100 per cent general increase in construction costs since 1938, and at the same time indicate the result of efforts being made to reduce both construction and annual production costs. Of the 45 post-war plants reported in the 1948 and 1949 supplements, five are classed as of the outdoor type and nine of the semi-outdoor type. Moreover, several post-war additions to the older plants are of the semi-outdoor type of construction. Attention is called to the fact that the majority of the stations that went into service during the year, as well as most of the 75 plants scheduled for 1950–1953 service, are following the trend toward the unit arrangement of one boiler per turbine, minimum housing, and centralized control.

Space does not permit reproducing data from all 245 plants listed, hence the accompanying table is compiled from certain essential data relating to the 26 new plants (identified in the complete supplement) most of which went into service last year. It will be noted that the initial cost per kilowatt of installed capacity varies over a wide range, from $98 in the case of one medium size outdoor gas-fired station in the Southwest to a high of $230 for a 50,000-kw pulverized-coal-fired on the Pacific Coast. The largest plant in the group and, incidentally, the one with the lowest station heat rate, cost $130 per kilowatt.

As is well recognized, cost per kilowatt is subject to several interpretations, depending upon whether it is based on rated capacity or maximum capability and whether there are included land and certain construction intended to form a part of future extension. Presumably the figures reported by the Federal Power Commission apply to total cost to date of reporting based on the rated capacity installed at that time.

In these new plants labor, as a component of production expense, is generally less than is recorded for the pre-war plants. This is attributable to more centralized control, one and two level operation, unit design, and the

DATA ON TWENTY-SIX NEW STATIONS

Plant No.	Location	Capacity, Kw	Steam Conditions, Psi/F	Fuel	Production Cost, Mills per Kwhr† Fuel	Labor Mills	Total	Initial Cost per Kw Dollars	Station Heat Rate, Btu per Kwhr
1	South	120,000	850/900	P. C. & G.	2.49	0.37	3.06	101	Coal—11,599 Gas—12,408
2	So. East	24,000	600/825	G. & O.	2.62	0.37	3.33	.....	15,305
3	Pac. Coast	20,000	1000/915	G. & O.	5.37	1.00	7.23	199 (outdoor)	14,845
4	South	60,000	1250/915 600/835	O.	5.21	0.90	7.02	..... (outdoor)	14,319
5	South	45,000	850/900	P. C.	4.47	1.34	6.79	144	12,632
6	Midwest	120,000	850/900	P. C.	2.44	0.45	3.16	.....	..
7	Midwest	40,000	850/900	P. C.	2.59	0.61	3.47	216	11,045
8	Midwest	26,500	850/900	P. C.	3.91	0.38	4.54	.....	13,643
9	Midwest	120,000	850/900	P. C.	3.51	0.25	3.98	140	11,143
10	No. West	12,500	650/825	St.* & G.	2.86	0.87	4.12	226	13,790
11	No. West	25,000	650/825	St.* & G.	4.35	1.13	6.12	204	14,597
12	So. West	77,000	850/900	G.	1.33	0.26	1.76	98 (outdoor)	11,827
13	East	330,000	1500/1050	P. C. & O.	2.89	0.28	3.40	130	10,437
14	East	44,000	1250/950	O.	3.79	0.47	4.72	221 (semi-outdoor)	11,116
15	East	30,000	850/900	St.*	3.62	0.43	4.33	204	13,017
16	East	40,000	1250/950	P. C.	3.30	0.38	4.13	.....	10,892
17	East	22,000	850/900	P. C.	4.16	0.46	4.96	201	12,262
18	No. West	15,000	400/825	Lig.	5.75	1.11	7.46	216	13,360
19	Midwest	120,000	1250/950	C., O. & G.	3.43	0.30	3.87	.....	10,951
20	East	70,000	850/885	P. C.	2.52	0.29	3.00	166	12,090
21	East	150,000	1250/925	P.C.	2.19	0.40	2.76	187	11,481
22	So. West	132,000	850/900	G.	0.94	0.14	1.20	..... (outdoor)	12,477
23	So. West	75,000	850/900	G.	0.98	0.18	..	67 (semi-outdoor)	15,046
24	So. West	50,000	600/835	G.	0.68	0.33	1.37	(outdoor)	13,450
25	South	60,000	850/900	P. C.	4.24	0.36	4.91	.....	11,973
26	Pac. Coast	50,000	1250/950	P. C.	2.27	0.44	2.89	230	11,544

*Stoker.
† Items other than fuel and labor, but entering into the total production cost, have been omitted from this compilation but are given in the supplement.

many automatic features installed in these plants. For example, one 330,000-kw station reports a total of 112 employees or 0.3 employee per 1000 kw of installed capacity, and a two-unit plant of 300,000 kw has 103 employees. These are in marked contrast to some pre-war plants of comparable size which have an employee for every 1000 kw.

The net station heat rates of these 26 new plants range from 10,437 to over 15,000 Btu per kwhr, those in the higher range generally having the advantage of cheaper fuel. Incidentally, the plant with the best heat rate of the entire 245 listed in the Supplement is the Sewaren Station of the Public Service Electric & Gas Company of New Jersey. The other complete, new and old, stations listed as showing outstanding heat rates of less than 11,000 Btu per net kwhr are Port Washington of Wisconsin Electric Power Company, with 10,510 Btu; Russell of the Rochester Gas & Electric Company, with 10,892; and O. H. Hutchings of the Dayton Power & Light Company, with 10,950. These are all high-pressure, high-temperature installations, but at the time of reporting to the Federal Power Commission only one of these employed reheat. Furthermore, very creditable performances are reported for several stations in the 850 psi, 900 F range, notably B. C. Cobb Station of Consumers Power Co. with 11,143 Btu.

(*ASME Annual Meeting continued from page 61*)

design. An appraisal of the undergraduate curricula of eight recognized engineering schools leads to the conclusion that fuels are treated adequately for the majority of the undergraduates, but that more attention should be given in selected institutions to research and graduate programs in fuel technology.

"On-the-Job Training and Fuel Utilization" was the phase covered by **R. J. Brandon,** of the Detroit Edison Company. This kind of training can be divided into two broad classifications: first, the operating and technical training in plant utilization, and second, economic fuel relationships and utilization equipment together with developments in fuel production, processing and utilization. The first part may be achieved most satisfactorily by actual plant and equipment operation and maintenance. It should have the overall aim of correlating fuel properties and characteristics with plant operation and equipment used for its utilization. An important part of this training is the acquiring of the terminology of the plant, since the ability to speak the same language as the men operating the plant promotes understanding and interchange of information.

The second portion of training deals with economic relationships of available fuels. This requires the development of an economic analysis which can be presented as a clear, concise, understandable report, and the training program should include experience in performing this task. With constant changes in fuel production, processing and utilization, it is also important that the trainee be conversant with technical articles, trade magazines and technical meetings concerned with fuels and their utilization. Finally, although training will point to a particular job to be done, an endeavor should be made to broaden the perspective.

Prof. W. E. Reaser of Swarthmore College suggested some of the mutual benefits to be derived from what he termed "Cooperative Engineering Education at the Faculty Level." The plan is to have a group of engineering teachers from several schools working upon an industrial development project. By living together and taking advantage of opportunities for informal interchange of ideas, they can become acquainted with new philosophies and carry back to their respective campuses fresh and tried ideas from industry and from other universities. Such a plan also offers an opportunity for industry to show the kinds of jobs and type of training program for engineering graduates and allows teachers to work with some of these men after they have started employment. Faculty members may be able to view industry more realistically after participating in conferences with management during the course of the development project and thereby become more enlightened and capable teachers. The proposal might be expanded to have professors devote a sabbatical year in a similar industrial program.

Dr. C. C. Wright, of the School of Mineral Industries, Pennsylvania State College, made a survey of college courses devoted to fuel utilization. He found that the mechanical engineering curriculum appears to offer the most work on the undergraduate level. In 25 representative colleges an average of three credits (based on approximately 150 credits for graduation) were offered on fuels, of which two generally pertained to combustion topics and one to problems and techniques of fuel analysis. Chemical engineering curricula ranked next in the amount of undergraduate training in fuels. More work in this field is being undertaken on the graduate level.

Discussion

Several persons mentioned that there are no completely satisfactory textbooks for fuel engineering education. There is a danger that courses in fuels may become superficially descriptive, and one professor advocated that problem courses be taught, using analytical methods and chemical and material balances. Another engineer urged that students be impressed with the importance of innovation and new ideas to insure advances in more efficient fuel utilization. It was pointed out that in the coal industry mining techniques have progressed more rapidly than adoption of improvements in the more efficient utilization of coal.

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Some Notes on Burning Coke Breeze

There is little that is new in the burning of coke breeze, but some recent inquiries from readers indicate that problems concerning it arise from time to time and such information may not be widely disseminated; hence these notes.

COKE breeze, or "braize," is the term applied to the fines resulting from the production of metallurgical or domestic coke from the distillation of bituminous coal. Its characteristics vary with the original fuel and the temperature of distillation, that from by-product coke ovens being harder and more abrasive than that produced in the manufacture of city gas, the coke from which is more or less friable. Beehive coke ovens have now largely been displaced by the by-product ovens.

There is also breeze from petroleum coke which is a residue from the refining of crude oil by the cracking process. This will be dealt with later.

The first-mentioned coke breeze is usually of a size that will pass through a $^{5}/_{8}$- or $^{3}/_{4}$-in. round hole screen and may contain up to as much as 40 per cent under size. The heating value ranges from 11,400 to 11,800 Btu per lb, with 12 to 20 per cent ash and volatile seldom exceeding 5 per cent, and usually less. The fixed carbon averages from 65 to 70 per cent.

Although attempts have been made to burn it in pulverized form, mixed with bituminous coal because of its low volatile, this was found impractical owing to the prohibitive maintenance from excessive wear on the mills, high power required and segregation of the two fuels. Therefore, the breeze is usually burned on traveling grate stokers. When so burned, preference calls for at least 20 per cent undersize and the minimum sizing is governed by the permissible carbon loss from siftings through the grates and from carryover into the gas stream at high burning rates.

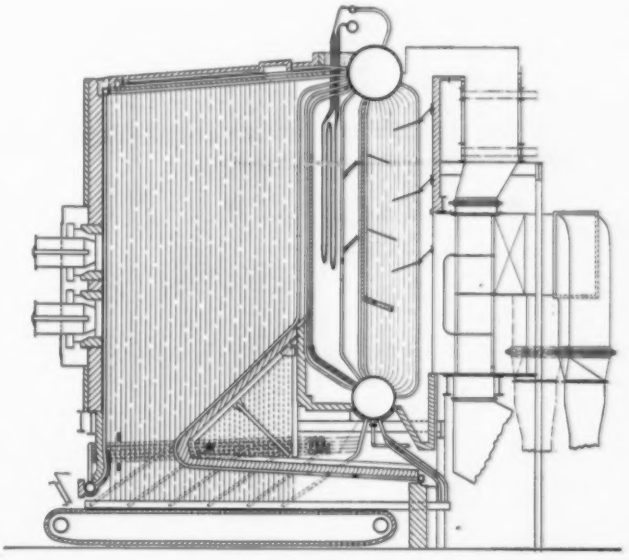
Furnace design is similar to that usually employed for burning Nos. 3 and 4 buckwheat with forced draft. A long rear arch is generally preferred because of its stabilizing effect on ignition and ability to deflect the fine particles in the gases onto the incandescent fuel bed, although combination arches are sometimes used. Where burning rates in excess of 35 lb per sq ft per hr are anticipated, it is advisable to provide cinder-arresting equipment. Moreover, water-cooled furnace walls and arches are desirable because of the relatively low ash-fusion temperature of the coke.

Efficiencies obtainable when burning coke breeze on a traveling grate stoker vary with the burning rate and are comparable to those obtainable when burning No. 3 buckwheat. Maximum efficiency usually corresponds to a burning rate of around 25 lb per sq ft per hr. Practically smokeless combustion is achieved because of the low volatile content.

In a number of steel plants coke breeze is burned on traveling grate stokers, either as primary or secondary fuel, in conjunction with blast furnace gas, according to its availability. The accompanying sketch represents a typical installation of this kind with a water-cooled arch. Furthermore, in at least one case coke breeze has been burned in combination with small-sized anthracite by firing in layers. By means of a divided hopper the anthracite is fed on the bottom, next to the grate, and the coke breeze on top. Blast-furnace gas is used as supplemental fuel.

Petroleum Coke Breeze

As previously mentioned, this fuel is a by-product of the refining of crude petroleum by the cracking process. It represents the screenings from petroleum coke sold for domestic heating or industrial use and is spongy and oily.



Typical setting with long rear arch

It disintegrates readily and is not well adapted to transporting. For this reason it has often been burned at the source, either under oil stills or for boiler fuel. Characteristics depend to some extent upon the oil and the degree of refining; but in general, the heat value is around 15,000 Btu per lb. It runs very low in ash, under 2 per cent; the volatile is usually from 8 to 12 per cent, but may run considerably higher, and the fixed carbon is around 90 per cent. The ash-fusing temperature is usually in the neighborhood of 2400 F, but in some cases runs much lower.

Petroleum coke alone, because of its low ash content, cannot be burned on traveling grate stokers, as there

would be inadequate protection to the grates. Moreover, mixtures of petroleum coke and bituminous coal have not proved satisfactory as the coke tends to fuse with the coal and block the air passages in the grate. Also such a mixture is difficult to maintain because of the different densities of the two fuels which produce segregation in the bunkers. To obviate such conditions alternate firing in layers, similar to the case previously mentioned, with by-product coke and anthracite, has been employed in a few cases.

Burning on Spreader Stokers

Limited experience has been gained in burning petroleum coke on spreader stokers where firing rates of 30 to 35 lb per sq ft of grate per hour appear desirable. At least an inch of ash should be maintained on the grate. The coke burns with a short flame and there is very little stack discharge.

Also, to some extent, petroleum coke has been burned in pulverized form since it is much easier to grind than by-product coke. Where it runs low in volatile it has been burned in combination with oil or gas as supplementary fuels. Generally, less excess air is required than with coal, and this results in higher CO_2 at the furnace outlet.

However, the largest markets for petroleum coke are for the manufacturer of carbon electrodes, dry cells, carbide abrasives and as an ingredient in artificial fertilizers, where it apparently has greater economic value than when used for fuel.

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Facts and Figures

Eleven per cent of the area of Continental United States, or approximately 340,000 sq mi, contains coal.

•

Gas turbines designed to burn heavy oil, such as bunker C, must be started with lighter diesel oil.

•

In the realm of nuclear power, priority is being centered on development of submarine propulsion.

•

Copper frequently accompanies deposits of iron oxide in boiler tubes, but opinions differ as to the rôle, if any, that copper plays in corrosion.

•

The gain in thermal efficiency through increasing throttle temperature at high pressure from 1000 F to 1050 F figures about 1.3 per cent.

•

Many coals that clinker badly with a thick fuel bed can be burned with practically no clinkers if the fuel bed thickness is held to 4 or 5 inches.

•

An important ingredient of synthetic rubber is butadiene, which is produced from petroleum and natural gas.

•

To avoid troublesome deposits on steam turbine blades it is essential that silica content of the boiler water of high-pressure boilers be kept well below 5 ppm.

•

Luminosity is not a measure of the radiating capacity of a flame, inasmuch as a considerable portion of the radiation occurs below the range of visual observation.

•

Evaporation loss on a cooling tower can be determined from the fact that approximately 100 lb of water will be cooled through a range of 10 deg F by the evaporation of one pound of water.

•

With units equipped for overfire air, it is usually well to disregard this air when figuring forced-draft fan capacities, as it may be desirable at times to operate at high loads without overfire air.

•

A recently published survey of the Japanese electric power industry placed the installed generating capacity at approximately nine million kilowatts, of which 68 per cent is hydro and 32 per cent thermal.

•

Energy use last year in the United States, according to Eugene Holman, president of Standard Oil Company of New Jersey, amounted to 32,100 trillion Btu obtained from 468 million tons of coal, 21 billion barrels of oil, 5.5 trillion cubic feet of natural gas, and 96.5 billion kilowatt-hours of hydroelectric power.

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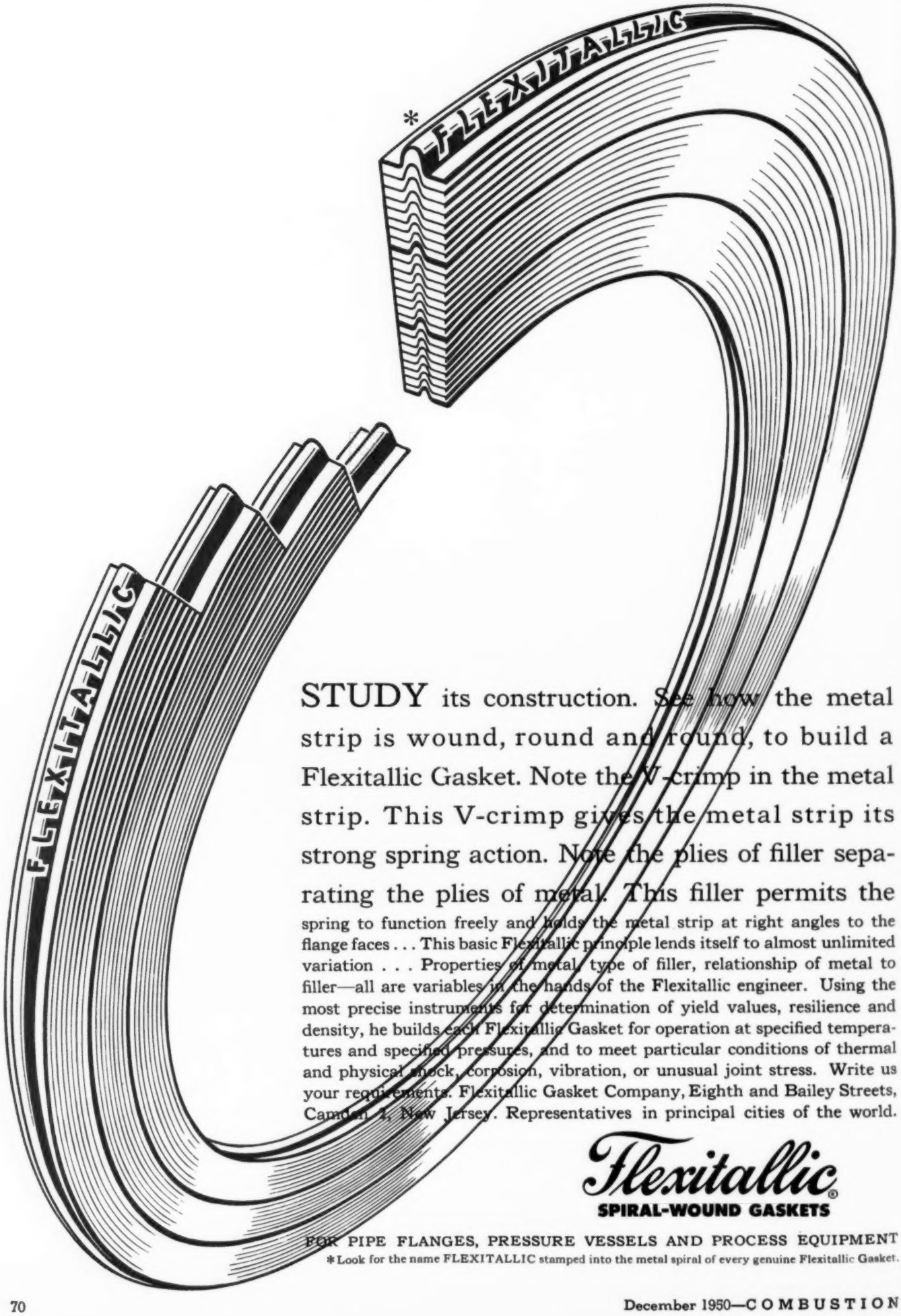

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Standardization of British Steam Turbine Plants

A PAPER presented by I. V. Robinson of the British Electrical and Allied Manufacturers' Association before The Institution of Mechanical Engineers on November 24 tells of the extent to which standardization of turbines and auxiliaries has been contemplated and put into effect in power plant practice in Great Britain.

There are at least three distinct aspects of this type of standardization:

(1) The simplification or reduction in number of component parts of equipment.

(2) The standardization of capacities of complete units, of various components and subassemblies, and of operating conditions, both mechanical and electrical.

(3) The standardization of station design to allow repeated use of arrangement drawings.

Simplification is a process that is undoubtedly adopted by every equipment builder. It may be used in connection with such components as oil pumps, valve chests and turbine governors.

In the past capacities of turbines have varied considerably and in some cases by a comparatively small amount for no discernible reason. Units in Great Britain have been installed in sizes from 10 to 60 mw by steps of 5 mw (except perhaps 35 and 55 mw). Beyond this upper figure there are a few units of 75, 100 and 105 mw.

Consideration has been given to the adoption of the next size larger than 60 mw, and it is believed that a 100-mw unit may prove useful. Hydrogen cooling is expected to provide a means whereby the same weight of stator windings will permit a greater output than with air cooling, due to decreased windage and reduced losses. Up to the present hydrogen cooling has been designed for 15 psig, although units will give their rated output at $^1/_2$ lb. In the future it is expected that generators will be designed for a hydrogen pressure of 30 psig, thus providing a further increase in electrical output.

In 1947 the British Ministry of supply issued an order which prohibited the manufacture, except by license, of any steam turbine above 10,000 kw except for 30,000 and 60,000 kw. For the former, steam conditions are stipulated as 600 psig, 850 F, and for the latter they are 900 psig and 900 F.

The British Standards Institution Steam Turbine Committee has suggested that for the next standard size of 100 mw the steam conditions at the turbine stop valve should be 1500 psig and 1050 F. Under these conditions it is essential that the boilers be capable of maintaining very steadily the total temperature of the steam. It is also essential that stresses should be such that equipment have a useful life of at least 100,000 hr and that it be capable of being started and stopped daily.

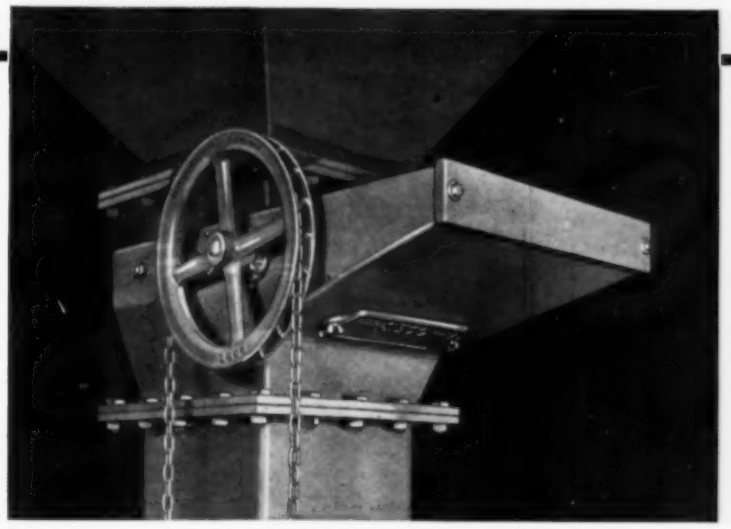
Representatives of the British Steam Turbine Committee recommended at a meeting held under the auspices of the International Electrotechnical Commission adoption of ratings and operating conditions as in the accompanying table. Final feedwater temperature is usually from 60 to 70 per cent of the saturation temperature of the steam supplied to the turbine.

RECOMMENDED RATING WITH STEAM PRESSURES AND TEMPERATURES

Continuous Maximum Rating, Kw	Steam Pressure at Turbine Stop Valve, Psig	Steam Temperature at Turbine Stop Valve, F	Maximum Feedwater Temperature, F	No. of Extraction Points
10,000	400	800	300 ± 10	3 or 4
20,000	400	800	300 ± 10	3 or 4
	600	850	335 ± 10	4 or 5
30,000	600	850	335 ± 10	4 or 5
60,000	900	900	375 ± 10	5 or 6
100,000	1500	1050	410 ± 10	6

Owing to the variation of the temperature of available cooling water it has been considered practically impossible to standardize the turbine exhaust pressure. However, a compromise is to design two exhaust ends for each turbine frame, one for use in a station with a natural supply of cooling water and the other in a station using cooling towers.

In adopting this compromise, it was assumed that the recooled water would be at a temperature of 75–80 F, justifying a vacuum of 28.0 to 28.5 in., whereas with a natural supply of cooling water it was generally assumed that the temperature would be 60 F, justifying a vacuum of about 29 in. With an atmospheric temperature of 60 F and a wet-bulb temperature of 51 F, the minimum cooling water temperature to be expected from a tower would be about 75 F. However, the average atmospheric temperature would be quite appreciably below 60 F, and therefore the temperature of the cooling water would be sufficiently below 75 F for a considerable proportion of the year, so as to justify designing the condensing plant for a water temperature less than 75 F, perhaps between 60 and 65 F. This does not differ greatly from the temperature of the natural supply of water. Allowing for the comparatively small por-



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tion of the year when the recooled water is at 75 F or above, it is suggested that satisfactory overall performance may be obtained by using the same exhaust end for either a natural or a recooled supply of water. This would assist standardization materially.

Present practice for turbines up to 30 mw is to provide an evaporator with bled steam supplying the vapor to a feedwater heater normally connected to a lower bleed point. For sets of 60 mw and larger it is usual to supply a high-pressure evaporating plant operating independently of the associated turbine.

Plant Standardization Suggested

Standardization of design of complete power stations is a field which the author believes should yield good results. It should be possible to take the complete arrangement drawings for one power station and to erect a duplicate of the station on another site. It is understood that this has been, and is being, done to a small extent in the United Kingdom and in continental European countries. The application of this form of standardization may present difficulties owing to the variation in the contour of the available sites, in the relative positions of natural water supplies, and of transportation facilities. This development should reduce the time required for completion of a station by eliminating the considerable period which passes now before arrangement drawings have been approved by all interested parties. It should also make possible the adaptation of existing drawings, and by reducing the time demands on designers and draftsmen it may allow them to devote more effort to progress in designing improved plants.

Although standardization offers many advantages by reducing the amount of design and drafting work, great care should be taken to ensure that it does not prevent progress. This point is thoroughly appreciated by the British Electricity Authority and has been guarded against by their practice of ordering approximately 20 per cent of their annual requirements in plants of advanced design. By so doing British manufacturers are enabled to try out new schemes, and the British Electric Authority obtains a more economical plant without sacrifice of availability.

As Others See Us

The November issue of *Engineering and Boiler House Review* (London) reviews the report of two British teams, each of sixteen members, who recently returned from an extended inspection of American central stations and distribution systems.

Comparing the use of electricity in the United States with that in Britain, they observed that the American industrial worker employed about three times as much electricity as the British worker, and that within twenty years the average annual per capita use of electricity in the United States is expected to increase to approximately 4800 kwhr.

Stating that technical development in the power field in the United States is far ahead, attention is called to the large generating units, higher steam pressures and temperatures, widespread employment of the unit system of single boiler and turbine, centralized control and high load factors, all contributing to constantly improving efficiencies and lower costs per unit of electricity. At the newer stations, economy of manpower resulting from the large size of generating units, centralized control and group maintenance is very marked.

It was pointed out further that the smallest new turbine-generator seen during the tour was 60,000 kw, which is the capacity of the largest standard British set; and the comment was made that establishment of a much larger standard machine in Britain, together with employment of a unit boiler to suit it, would substantially increase the rate of commissioning new plants in that country.

A thing that greatly impressed the British visitors was the comparatively short time required for the construction of new American power stations. This they attributed to a high rate of output by the equipment manufacturers, coupled with careful planning and organization of the job. They stated that the time required to complete and commission such a station, from start to finish, is little more than half the time usually taken in Britain.

Rating Steam Generating Units

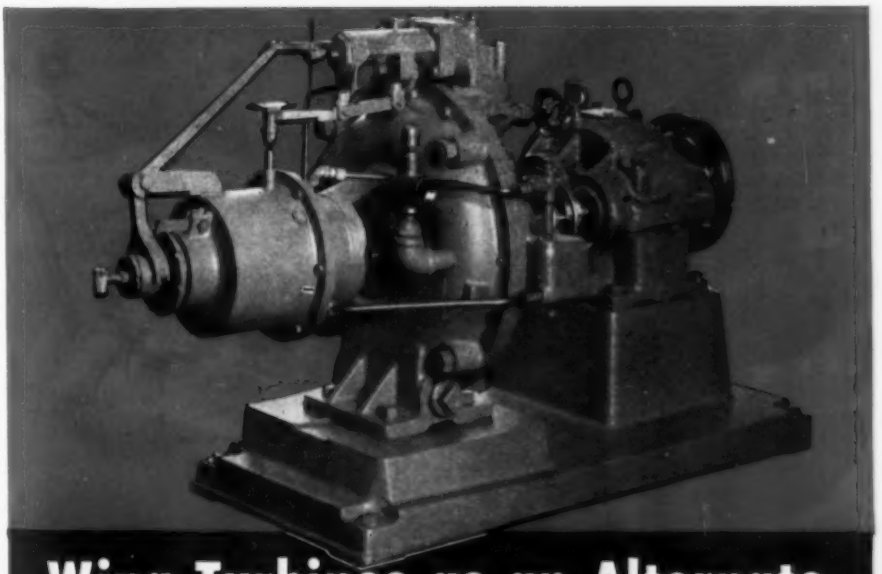
I was interested by your editorial in the October issue of COMBUSTION regarding the rating of steam generating units, and am heartily in agreement with your statement that the proper measure of capacity is the heat input to the water and steam. However, the difficulty in this is just that the Btu per hour is too small a unit, and there is no common method of expressing large multiples of the unit.

The watt, which is also an energy unit, does have commonly accepted multiples as kilowatt and megawatt. Therefore, we might get acceptance of boiler ratings in watt multiples. But this should not be dependent on turbine performance. The boiler rating should be, precisely, the heat added to the working substance, expressed in megawatts, instead of Btu per hour.

Thus the turbine thermal efficiency would be merely the ratio of megawatts on the bus bar to megawatts boiler output. The system would be equally applicable to reheat or regenerative cycles, using steam, mercury, Dowtherm or what have you.

We might even envisage the day when fuel heating values would be expressed in kilowatt-hours per pound, and specific heats in watt-hours per pound. This would certainly be a happy day for engineering students.

R. J. SWEENEY
Assistant Professor
Department of Mechanical Engineering
Lehigh University



Wing Turbines as an Alternate Source of Auxiliary Drive

The use of turbines as an alternate source of auxiliary drive is good business in these days of urgent production and uncertain industrial conditions. When electric motor drive is subject to power failures due to strikes, fires, floods, hurricanes (or bomb attack), the ability to continue with steam auxiliaries is an advantage that is worth many times the cost of the alternate equipment. And the use of Wing Steam Turbines for such services as pumps, compressors, fans, blowers, generators, etc., can cut power costs by acting as a reducing valve on boiler steam for use in process and heating.

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54 Vreeland Mills Road, Linden, N. J.
Canadian Factory: Montreal, Canada

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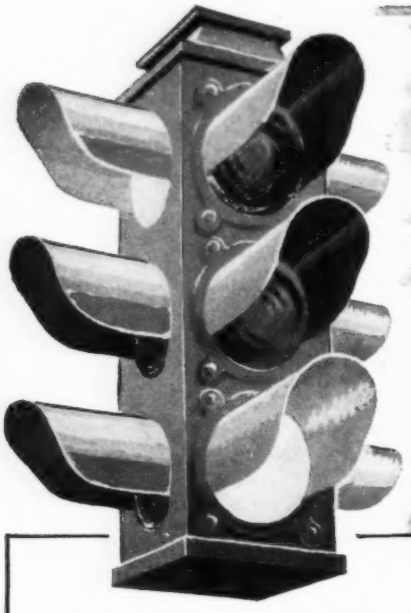
AUXILIARY TURBINES



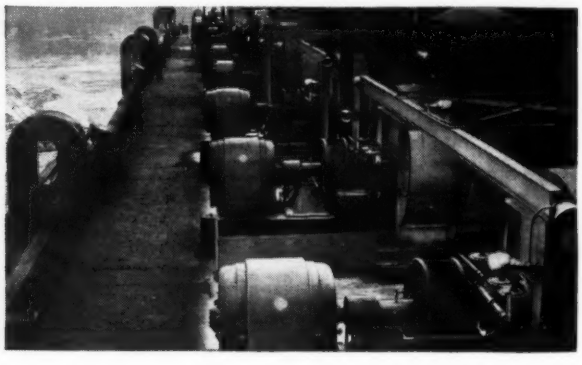
DRAFT FANS GO on GREEN

A Big Draft Job Handled Capably by Green Fans

Twenty-four large Green Fans take care of a heavy draft load at the Venice (Illinois) Plant of the Union Electric Co. of Missouri. Each of six boilers has two sets of Green Fans, each set consisting of one induced draft fan and one forced draft fan coupled to one motor as a unit. With the heavy demands on this station, all boilers are usually in service continuously, thus throwing an unrelenting burden on the fans.

Engineers whose responsibility it is to recommend or accept draft fans for large power plants certainly want efficiency and low operating costs. But they don't overlook the maintenance and replacement angles. They want the sound designs of competent experienced fan engineers. They also want the care in construction that is found in shops of a company that has built up an international reputation as the "authority" on draft fans. They know that such a company will not tolerate sloppy shop work.

Green is this authority on mechanical draft fans.



Have You a Copy of Our Fan Bulletin No. 168? If not, we shall be glad to send you one.

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Veteran Engineer Honored

John Hunter, well-known retired utility engineer and past vice president of the A.S.M.E., was honored on November 1 at Orlando, Fla., by being made a Fellow of the Florida Engineers' Society in recognition of his many contributions to the engineering profession. Still robust at 85, Mr. Hunter now resides at Winter

Park, Fla. The above photograph shows him receiving the fellowship certificate. Left to right are John B. Miller, secretary of the Florida Engineers' Society, A. P. Michaels, past president of that society, Mr. Hunter, Curt Stanton, Orlando Utilities Commission manager, and Arthur Hunter of New York, son of the honored guest.

Business Notes

Edward Valves, Inc., has added Samuel E. Bowler to its executive sales and engineering staff. Mr. Bowler recently retired as electric operating and engineering manager of the Long Island Lighting System.

The Air Preheater Corp., Wellsville, N. Y., announces the appointment of W. R. McKee as purchasing agent, succeeding L. F. Keagle, recently deceased.

Cochrane Corp., Philadelphia, has advanced E. J. Bookout from eastern sales manager to the position of general sales manager.

Manning, Maxwell & Moore, Inc., Bridgeport, Conn., has appointed R. F. Attner manager of valve distributer sales. Mr. Attner joined the company in 1922 and since 1945 has been assistant to the sales manager for Hancock valves.

The Dampney Company of America, Boston, has appointed Allied Services Inc., Charleston, W. Va., as its sales and service representative for its protective coatings in southern West Virginia.

E. F. Drew & Co. has named Martin P. Kerins as Connecticut representative, with headquarters in Bridgeport, for its Power Chemicals Division.

The Kuljian Corp., engineers and constructors, Philadelphia, has appointed Frank R. Simpson director of research and development. For the past eight years Mr. Simpson has directed research projects for the Franklin Institute.

New Books

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Steam Plant Operation
Second Edition

By Everett B. Woodruff and H. B. Lammers

This book, originally brought out in 1935, is aimed at presenting a practical text for the guidance of engineers engaged in operating stationary steam plants. It provides basic information on the combustion of fuels, types and certain construction details of fuel-burning equipment, boilers, their settings and auxiliaries; also steam engines and turbines together with their auxiliaries. Moreover, considerable space is given to the safe and efficient operation and maintenance of steam plant equipment. At the end of each chapter is a list of questions, with specific text references as to where the answers can be found. This feature should be of great assistance to those preparing to take examinations for an operating license.

In the present edition the text has been largely rewritten to bring it up to date as regards present designs of equipment and current practice.

There are 542 pages, 6 × 9 in., bound in cloth, and the price is $7.

Heat Insulation

By Gordon B. Wilkes

This book represents a compilation of many types of information pertaining to heat insulation over a wide range of temperatures. In a chapter on "Methods of Determining Heat Transfer Coefficients" there is an explanation of the guarded-plate and guarded-box methods, a description of a pipe-insulation tester, and an account of the several "Northrup" methods. Succeeding chapters detail factors affecting the coefficient of thermal conductivity and types of insulating materials. There is also a chapter entitled "Reflective Insulation" which is largely based on work carried out in the Heat Measurements Laboratory at M.I.T., where the author is Professor of Heat Engineering.

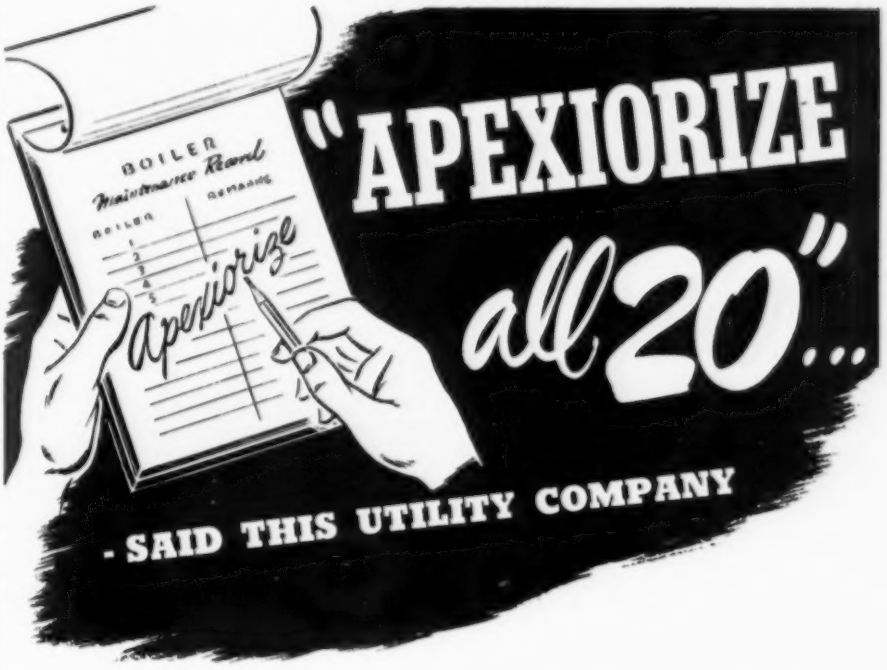
The Appendix contains five useful tables: Coefficients of Thermal Conductivity, Specific Heat and Thermal Diffusivity, Emissivity and Reflectivity of Various Substances, Coefficients of Heat Transmittance for Building Walls with Calculated U Values, and Water-Vapor Permeability of Various Materials.

There are 224 pages and the book is priced at $4.

Plant Engineering Handbook

Edited by William Staniar

This is a book intended to supplement the usual type of engineering handbook for those people in industry who are responsible for organization, design, construction, operation and maintenance. It was prepared by a staff of 87 specialists



And with the project already half completed, this company's central station steam-generating units will soon be internally protected with Apexior Number 1 surfacing.

Why are these and scores of other high-temperature, high-pressure units constantly being added to the ranks of Apexiorized boiler steel?

We could give you many reasons. For one, there's the matter of proper protection if you're considering chemical cleaning. Apexior saves metal by preventing acid contact. Because it discourages deposit formation and bonding, it also permits easier, quicker cleaning.

Basically, though, there's just one reason for Apexiorizing any boiler and that is to build into it an operating factor of safety not otherwise obtainable. With Apexior guarding internal surfaces, an expendable maintenance item — not costly metal — becomes your first line of defense. Should operating conditions deviate for any reason from the ideal, Apexior takes the consequences while steel, safely isolated, retains all of its initial strength and soundness.

Apexiorizing is a simple, inexpensive way to make a good boiler better — something we've been specializing in now for thirty-three years. Our 8-page Bulletin 1530 gives you all the facts — and if you'll give us the necessary data on your boilers when you write (number and size of tubes and drums), we'll be happy to include a quotation.

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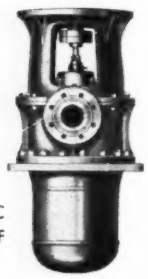

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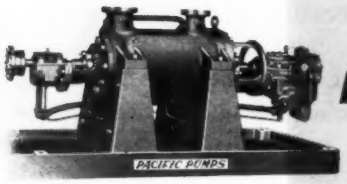

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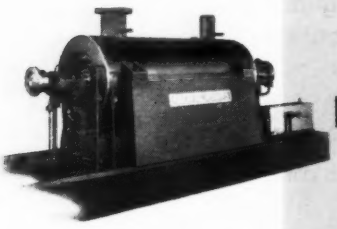

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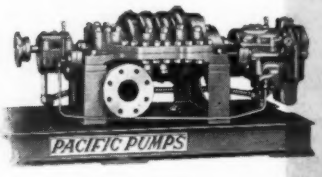

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TYPE	QUANTITY	Pounds Per Hour	Degrees Temp.	Pounds Pressure
WBF	11 Pumps	47,700	259F	710
ABF	3 Pumps	230,000	281F	1110
	3 Pumps	358,120	220F	1300
	4 Pumps	350,000	300	1060
IBF	3 Pumps	425,000	310F	1825
	3 Pumps	495,000	306F	1619
	2 Pumps	450,000	310	1600
	6 Pumps	405,000	305	1750
	3 Pumps	450,000	310	1825
JBF	2 Pumps	163,600	260F	490
	1 Pump	117,500	250F	775
	3 Pumps	300,000	240	1000

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from 45 industrial organizations and five universities.

The opening section, "Basic Costs and Cost Reduction," is useful for making estimates in which long-term effects are important considerations. In addition to costs this chapter provides data on man-hours per unit on such commodities as food products, textiles, paper, chemicals, rubber, leather, iron and steel, machinery, automobiles and coal mining. Succeeding sections take up various aspects of management engineering, construction materials and structural design, fire prevention, plant maintenance, water treatment, power plants., etc.

The section on power plants makes up nearly 15 per cent of the handbook and is quite comprehensive in its coverage of power-plant thermodynamics, fuels, fuel preparation and burning equipment, boilers and boiler auxiliaries, graphic power measurement, steam turbine-generators, gas turbines, compressors and pumps, hydraulic turbines, mechanical-drive turbines, and ash-handling systems. Some of the material on boilers and fuel burning equipment has been adapted from *Combustion Engineering*, edited by Otto de Lorenzi. A concise summary of power-plant thermodynamics was prepared by H. L. Solberg and C. L. Brown of Purdue University, and an informative contribution on gas turbines was written by Dr. J. T. Rettaliata.

This handbook, with its 35 sections and nearly 2000 pages of information, provides many of the essentials of good practice in modern industrial plants. It has a flexible binding and sells for $15.

Gas Producers and Blast Furnaces

By Wilhelm Gumz

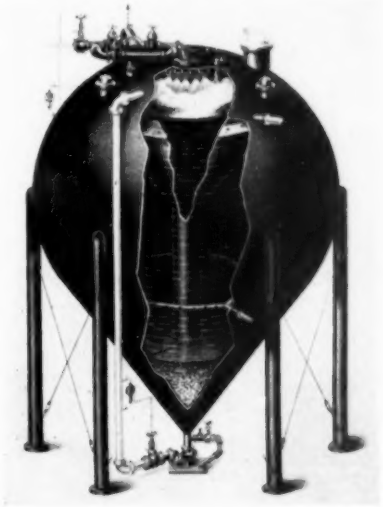
The usual approach to gasification processes has been an empirical one with little attention given to the development of theory and calculation methods. This book represents an attempt to find a better understanding of the reactions going on in the shaft of gas producers and furnaces by developing means of calculation. In this way it is hoped that the processes may be mastered and ways of improvement may be suggested.

Part I of the book is devoted to gas producers with chapters on gasification reactions, gas composition at equilibrium and at incomplete equilibrium, and mathematical treatment of gas-producer performance. Part II takes up blast furnaces including gas composition and method of computation, while Part III deals with reaction kinetics. The calculations are based on the metric system, which is also used in tables in the Appendix on properties of gases, steam-air or gas mixtures, enthalpy of gases, and equilibrium constants.

The author has had a broad background of experience in Germany as editor of *Feuerungstechnik* and in research on coal gasification and distillation. In this country he was associated with Hydrocarbon Research, Inc., for several years and is now a consultant to the Battelle Memorial Institute.

The book contains 316 pages and sells for $7.

NEW EQUIPMENT

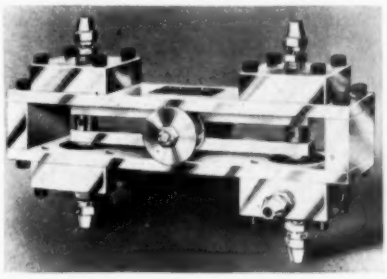


Sedimentation Tanks

A marked improvement in the design of sedimentation tanks for hot process water softeners has been developed by the Graver Water Conditioning Co., New York, N. Y. Known as the Graver Sphericone, the new design consists of a hemisphere mounted on top of a cone. The inverted cone provides a uniformly increasing area from tip to circular top which aids in the correct functioning of the tank, while the hemisphere provides added structural strength. The raw water, steam and chemical inlets, spray heater, deaerator and treated water collector are all mounted in the hemisphere; the inverted cone contains the downtake, sludge bed and the rising zone of the water being treated.

Ratio Totalizer

Hagan Corp., Pittsburgh, Pa., has announced the "Hagan Ratio Totalizer" which is a pneumatically operated control



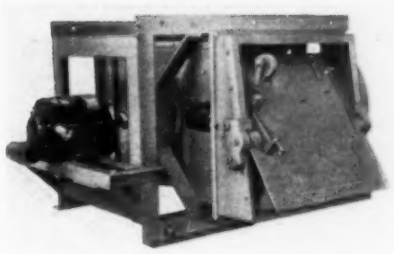
mechanism for combining input control pressures and spring forces in any desired manner to produce a single output control pressure. It is designed to be used in computing circuits for such functions as addition, subtraction, multiplication and division of control signals. Field tests have indicated successful applications in general process control and in central station and industrial power plant regulation.

Double Hung Arch

The George P. Reintjes Co., Kansas City, Mo., has developed a double hung insulated refractory arch which incorporates the pendulum hung method of supporting arches. Each unit of arch tiles is movably suspended from a tube which in turn is supported from the overhead framework by adjustable I or U bolts. Standardization of arch shapes is such that the thicknesses of the insulation on any arch are to all practical purposes unlimited, and stock-sizes of insulating blocks can be used without overheating supporting metal.

Instrument Piping Valves

Valves for instrument piping and general use which reduce threaded connections from ten to three are now being made by Jerguson Gage & Valve Co., Somerville 45, Mass. The valves combine unions, nipples, reducers, elbows, tees, valve and drain valve into one space-saving unit, making possible the use of one valve to replace the multiple set-up previously required. There are nine styles, some of the features of which include a safety shut-off, a double-seating stem for repacking under pressure, regrindable and renewable seats, and throttling stem.



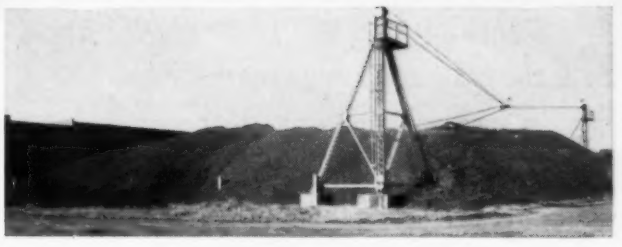
Draft Inducer

For more precise control of furnace draft the L. J. Wing Mfg. Co., Linden, N. J., has made available a "Draft Inducer with Integral Barometric." The combination of variable speed motors and integral barometric dampers is said to permit the operator to achieve the highest combustion efficiency. A hinged explosion gate is made a part of the barometric to relieve any excessive pressures that may develop in the breeching.

Globe Valve

A new 200-psi bronze "W.S." globe valve has been made available by the Wm. Powell Co., Cincinnati, Ohio. Features include extra high lift of the disk, large flow areas above and below the seat, and wide nominal pipe size opening through the seat. Valves are manufactured with screwed ends in sizes from $^1/_8$ to 3 in., inclusive.

SAUERMAN For Better COAL STORAGE at LOWEST COST



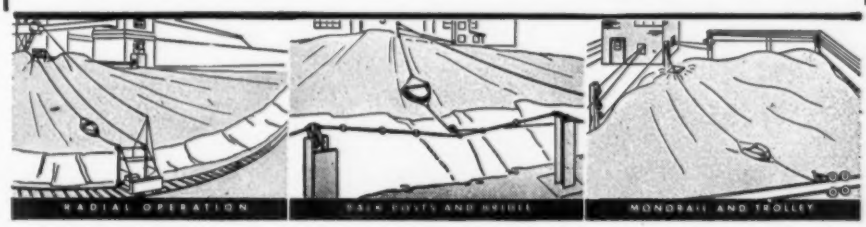
How to Build Safe Coal Piles with Least Labor

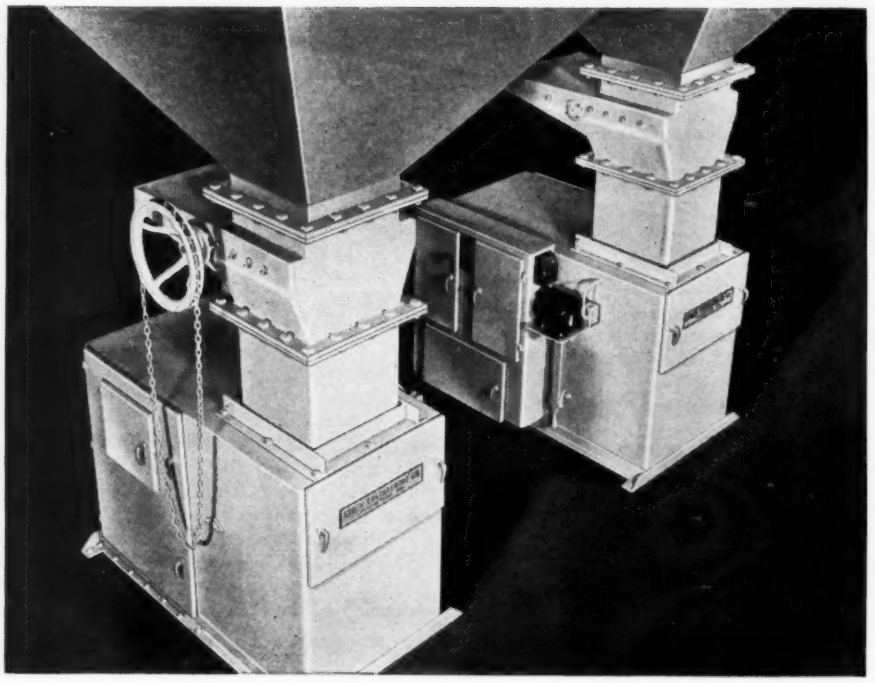
Coal piled by a Sauerman scraper machine is safe from spontaneous combustion because the scraper compacts the coal—rakes the fines into the voids—so there are no air pockets to generate heat. The operation is simple and economical. One man, sitting in a cab overlooking the storage area, controls every move of the scraper. With a large Sauerman unit, this one man can handle up to 400 t.p.h.

Sauerman engineers have devised many variations in scraper equipment to meet diverse conditions. One type of Sauerman installation is pictured above; three others are shown below.

For complete facts, write for Sauerman Coal Storage Book.

SAUERMAN BROS., INC. 550 S. Clinton St., Chicago 7, Ill.





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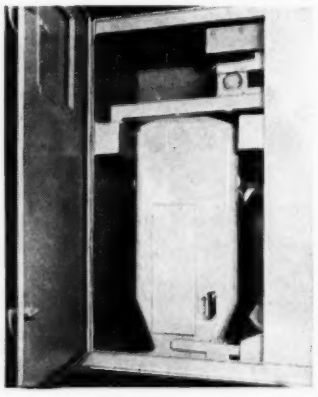
Large assembly door and feeder access door make it possible to remove the feeder and weigh hopper quickly as units. If the feeder support rails are also removed, the inside of the coal scale body is entirely free of operating parts. The inside of the scale is then clear for cleaning and painting. If this work is done occasionally, the scale body should last indefinitely.

The sub-assembly idea is exclusive with S-E-Co. Coal Scales. This is another reason why these units will give the best coal scale operation.



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